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A MONOGRAPH

OF THE

SILURIAN FOSSILS OF THE GIRVAN DISTRICT IN AYRSHIRE

WITH SPECIAL REFERENCE TO THOSE CONTAINED IN THE "GRAY COLLECTION"

FASCICULUS III.

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WITH SPECIAL REFERENCE TO THOSE CONTAINED IN THE "GRAY COLLECTION"

BY

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FASCICULUS III.

(THE ANNELIDA AND ECHINODERMATA, WITH SUPPLEMENTS ON THE PROTOZOA, CŒLENTERATA, AND CRUSTACEA)

WILLIAM BLACKWOOD AND SONS
EDINBURGH AND LONDON
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PREFACE TO THE THIRD FASCICULUS.

Since the present work was originally undertaken by us, fresh explorations in the richly fossiliferous Silurian area of Girvan, by Mrs Robert Gray and others, have brought to light a very large amount of additional material. Under these circumstances, as stated in the Preface to the Second Fasciculus, we decided to publish at once short Supplements dealing with the new material obtained in the departments of the Protozoa, Cœlenterata, and Crustacea, rather than to wait till the completion of the entire work might enable us to issue a "General Supplement."

This intention we have now carried out, and the present Fasciculus will be found to contain the above-mentioned Supplements, in so far as it was found practicable to prepare them. We have, however, allowed the Graptolites to stand over in the meanwhile, and we have also found it necessary to restrict the Supplement dealing with the Actinozoa to those forms only which would ordinarily be understood as "Tabulate Corals." We found it, in fact, impossible to include the Rugose Corals in the present Supplement, partly on account of the large amount of new material available in this group, and partly on account of the great labour attending the satisfactory investigation of this difficult division of the Palæozoic Corals.

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In addition, moreover, to the above-mentioned Supplements, the present Fasciculus contains descriptions of the Annelides and Echinoderms, which are known to us as occurring in the area under consideration. The plates which illustrate the text have, as before, been put upon the stone by our friend Mr Charles Berjeau, F.L.S., who has also drawn all except those dealing with the Corals and Protozoa; and we desire to take this opportunity of recording our gratitude to him for the care and skill which he has shown in the execution of his task. We may add that the present Fasciculus completes the first volume of the Monograph, and that we have therefore judged it expedient to append an Index of the forms which we have so far dealt with.

We have to express again our sincere thanks to the Royal Society for assistance from the Government grant—assistance without which it would be impossible for us to continue our work. We are also again much indebted to the authorities of the Museum of Practical Geology for the ready access to their unrivalled collection of British Fossils, which has been always granted us for purposes of comparison and study.

United College, St Andrews,
and Museum of Natural History, London,
October 1880.

A MONOGRAPH

OF THE

SILURIAN FOSSILS OF THE GIRVAN DISTRICT.

SUB-KINGDOM PROTOZOA (*Continued*).

CLASS RHIZOPODA (*Continued*).

(See *Fasciculus I.* p. 10.)

Genus CLATHRODICTYON, Nich. and Murie.

(Journ. Linn. Soc., vol. xiv. 1878.)

Gen. char.—"Skeleton ('sarcodeme') massive, closely resembling *Stromatopora* in superficial aspect and general appearance and structure, but differing in the fact that the concentric laminæ are minutely undulated, and inflected at short intervals, so as to give rise to successive layers of oval or rounded cells or vesicles, which are usually distinct, but at other times open into one another by the imperfection of their lateral boundaries. There are thus no 'radial pillars,' as independent structures; but their place is taken by partial or complete inflections of the horizontal laminæ bounding the interlaminar spaces, which are bent in such a way as to divide the space into complete or incomplete oval compartments.

Horizontal section simply reticulate. Surface tuberculate. (Nicholson and Murie, *op. cit.*)

Clathrodictyon vesiculosum, Nich. and Murie.

(Pl. XIX., fig. 2.)

Clathrodictyon vesiculosum, Nich. and Murie, Jour. Linn. Soc., vol. xiv. p. 220, Pl. II., figs. 11-13.

Spec. char.—Skeleton in the form of cake-like expansions, from about an inch to a foot in diameter, and from half an inch to two inches in thickness in the centre, but thinning out towards the circumference. Young specimens sometimes encrusting foreign bodies, but the unattached portions of the under surface being otherwise covered with a concentrically striated epitheca. Upper surface irregularly undulating and exfoliating concentrically round the elevated points. Surface smooth, not tuberculated. Internal structure of exceedingly fine and close-set horizontal or slightly undulating laminæ, of which about twenty occupy the space of 1-10th of an inch (counting in the interlaminar spaces as well). The horizontal laminæ are undulated and inflected at short intervals, so as to divide the interlaminar spaces into a series of minute lenticular vesicles or cells which often communicate laterally by imperfection of their boundaries.

Obs.—We have no reason to doubt the entire identity of the Girvan Stromatoporoids here described with those originally described by Dr Murie and one of the present writers, from the Clinton and Niagara formations of North America. The specimens which we possess from the Girvan area—the first Stromatoporoids which have been detected in the Silurian rocks of Scotland—are, it is true, smaller than the examples which we possess from America, and they appear to have been in general encrusting, rather than to have been attached by a pedicle and to have had a large part of the under surface free and epithecate. This difference is, however, almost certainly

to be ascribed to nothing more than difference of age or station in the two sets of specimens, and their internal structure is precisely the same.

Clathrodictyon vesiculosum is easily distinguished from the forms of *Stromatopora* proper by its want of any regular system of vertically disposed radial pillars, and by the resolution of the interlaminar spaces into a series of minute lenticular vesicles produced by often incomplete inflections of the undulated horizontal laminæ at short intervals. The great closeness of the horizontal laminæ at once separates the species from its ally, the *C. cellulosum,* Nich. and Murie, of the Devonian of North America.

Loc. and Horizon.—Not uncommon in the greenish mudstones (Upper Silurian) of Woodland Point, near Girvan. (Gray Collection.)

Genus HYALONEMA, Gray, 1835.

(Proc. Zool. Soc. III., p. 63.)

Hyalonema? Girvanense, Nich. and Eth. jun. (*sp. nov.*)

(Pl. XIX., figs. 1-1 *b.*)

Spec. char.—Rope of long cylindrical siliceous spicules of unknown length and very variable diameter, the largest being about 1-25th of an inch in thickness, while the smallest are 1-100th of an inch or less in diameter. The fibres, where well preserved, are traversed by a delicate axial canal, and are crossed at irregular intervals by horizontal or slightly curved transverse partitions. Terminations of the spicules, as well as the true skeleton-spicules and flesh-spicules, unknown.

Obs.—We propose the above name for a fossil from the Silurian rocks of Ayrshire, which we cannot doubt to be the siliceous rope of a sponge, more or less nearly allied to the recent *Hyalonema.* Our single specimen is a mere fragment of the rock, originally about three inches in length, enclosing

a portion of the rope, the component spicules of which are now no longer in contact, and are more or less widely distributed through the enveloping matrix. The spicules resemble those of the Carboniferous *Hyalonema* (*Hyalostelia*, Zittel) *parallelum*, M'Coy, sp., in being of very unequal sizes, as was pointed out in the case of the latter species by Professor Young and Mr John Young (Ann. and Mag. Nat. Hist., ser. 4, vol. xx., Pl. XIV., figs. 2 and 3). They show no traces of any diminution of their diameter (the long section figured in Pl. XIX., fig. 1 *b*, cuts the spicules somewhat *obliquely*, and therefore makes them appear to be fusiform); nor have we been able to find their terminal extremities. A careful microscopic examination has also failed to reveal the existence of any of the flesh-spicules, or of the proper spicules of the skeleton. The point by which the present species seems to differ more especially from *H. parallelum*, M'Coy, sp., is the presence in all the larger and in some of the smaller spicules of straight or slightly curved horizontal partitions; and it is on account of this peculiarity, principally, that we have separated it as a distinct species.

Our knowledge of this form is too scanty to allow us to affirm that it is really referable to *Hyalonema*, Gray; and it is simply as a provisional arrangement that we have placed it in this genus. When *Pyritonema*, M'Coy (Brit. Pal. Foss., p. 10), and *Acestra*, Roemer (Sil. Fauna von Sadewitz, Pl. VII., fig. 7 *a*, p. 55), come to be more fully understood, it is quite probable that our present form may prove to be congeneric with one or other of these imperfectly-worked-out types; but it would be useless at present to attempt any comparison.

Loc. and Horizon.—From a light grey limestone (of Lower Silurian age), Knockgeeran, near Girvan. (*Coll.*, Mr Charles Lapworth.)

SUB-KINGDOM CŒLENTERATA—(*Continued*).

CLASS ACTINOZOA—(*Continued*).

(See *Fasciculus I.* p. 25.)

Genus HELIOLITES, Dana, 1846.

(See *Fasciculus I.* p. 57.)

Gen. char.—"Corallum spheroidal, pyriform, hemispherical, or rarely ramose, composed of numerous closely contiguous corallites, which are divisible into two distinct series. The larger corallites are cylindrical, comparatively few in number, and furnished with twelve lamellar infoldings of the wall, of the nature of pseudo-septa, which fall short of the axis of the visceral chamber. Small corallites completely investing the larger ones, more or less regularly polygonal in form, provided with distinct walls, which are completely amalgamated with one another and with the walls of the larger tubes, and which are not known to be provided with any apertures allowing lateral communication. The small tubes have no septa, but have numerous straight and complete tabulæ, similar but somewhat less numerous structures existing in the large tubes. No columella." (Nicholson, Pal. Tabulate Cor., p. 243.)

Obs.—To the above generic diagnosis of *Heliolites*, we have nothing to add except as regards the condition of the septa. These structures are certainly normally lamellar, as above stated; and they vary much in their development, being sometimes quite marginal and rudimentary (*e.g.*, in *H. megastoma*, M'Coy, and in one of the forms ordinarily included under the name of *H. interstincta*, Linn.), while at other times they extend inwards for a distance of from one-half to two-thirds or more of the total distance between the wall and the axis of the visceral chamber. In the investigations which we have recently carried out as to the minute structure of a number of species of *Heliolites*, we have found that there is at least one

form—in other respects entirely agreeing in its characters with *H. interstincta*, Linn.—in which the septa are continued inwards to meet centrally in a more or less highly developed median reticulation, which might be regarded as a kind of trabecular pseudo-columella. We shall notice this feature more fully in speaking of the minute characters of *H. interstincta*, and need, therefore, say nothing further on this head at present. The only other point we have to notice is one concerning the possible existence of the septa as rows of spines, instead of as distinct lamellæ, as is normally the case in the genus. Thus, Dr Rominger (Foss. Cor. of Michigan, p. 10, 1876) describes a form of *Heliolites* which he terms *H. pyriformis*, Hall, in which the septa have the condition of vertical rows of spinules, thus resembling these organs in most of the *Favositidæ*. We have not ourselves found any undoubted form of *Heliolites* to possess spiniform septa; but the septa in certain species of *Plasmopora* (*e.g.*, *P. scita*, E. and H.) are composed of vertical rows of spines, which have a marked upward inclination, and are fused into lamellæ towards their bases. We have also examined a specimen from the Coniston Limestone of Westmorland which would seem to be referable to *Heliolites*, in which the free edges of the septa are terminated by a row of spines directed upwards.

In the First Fasciculus of the present work (p. 57) we have recorded the occurrence of *H. interstincta*, Linn., and of *H. Grayi*, E. and H., within the Girvan area. Since that was written, however, a number of specimens of *Heliolites* have been collected by Mrs Gray from the Silurian rocks of this region, and some of these present points of considerable interest. As the species of the genus are remarkably similar in internal structure, and differ principally in points relating to the proportionate size of the large corallites and the extent to which the small corallites are developed, we have found it necessary in the determination of these to institute a very careful comparative examination of a large number of forms. It may therefore be of advantage to students if we present

here a brief synopsis of the recorded species of the genus, so far as known to us, accompanying this with any observations to which our late researches have given origin.

1. HELIOLITES INTERSTINCTA, Linn.—Corallum discoidal or hemispherical, the large corallites about 1-17th of an inch (or two-thirds of a line) in diameter, and from half a line to a line apart. Small corallites polygonal, in from three to five rows. Condition of the septa variable.

We purpose giving a tolerably full description of this species, so need add nothing here to the above brief definition.

2. HELIOLITES SUBTUBULATA, M'Coy. — Corallum massive, the large corallites thick-walled and cylindrical, about half a line in diameter, and "generally more than their diameter apart." Small corallites very numerous, polygonal. Septa "small and indistinctly marked." (See *Palæopora interstincta* var. *subtubulata*, M'Coy, Brit. Pal. Foss., p. 16, Pl. I. C., fig. 2.)

Milne-Edwards and Haime (Brit. Foss. Cor., p. 250) identify this with their previously described *H. Murchisoni*, with which it agrees in the size of the large corallites. M'Coy's language as to the width of the intervals occupied by the small tubes is, however, so ambiguous, that it is difficult to judge if his form presents the wide interspaces so characteristic of *H. Murchisoni*, E. and H. The figures which he gives would make the intervals about equal to the large tubes in diameter. In view of this fact, and in our ignorance of the original types of M'Coy, we do not feel able to assert positively that *H. subtubulata* may not prove to be a good species. We should add that Dr Rominger has described a form from the Upper Silurian of North America under the name of *H. subtubulatus* (?) M'Coy, but he gives a very brief description of this, and states that the larger corallites are "only a half a millimeter wide," being thus considerably smaller than the corresponding tubes in M'Coy's species (*see* Foss. Cor of Michigan, p. 12). *H. subtubulata*, M'Coy, is stated to occur in the Coniston Limestone (Lower Silurian) and in the Wenlock Limestone.

3. Heliolites Murchisoni, E. and H.—We have examined specimens of this form from the Wenlock Limestone, both macroscopically and microscopically, and we find typical examples to possess the following characters: The corallum is discoidal when young, or subhemispherical when adult, its size being moderate (rarely over two inches in diameter). Under surface epithecate. Large corallites between 1-26th and 1-34th inch in diameter (between one-third and one-half line), separated by interspaces, which vary in diameter from 1-34th to 1-15th inch, but average about 1-20th inch. The small corallites are polygonal, thin-walled, in from three to six or nine rows, their diameter about 1-100th inch, more or less. The tabulæ of the large tubes are straight, and about 1-100th of an inch apart; those of the small tubes are horizontal, and vary from 1-100th to 1-200th inch apart. The calices of the large corallites are markedly circular, not exsert, thin-walled, and hardly crenulated by the minute septa.

The most marked features in this species are the small, round larger corallites, placed at distances which vary much in the same specimen, but which are almost always wider than the large tubes themselves; while the septa are very minute, and the small corallites are polygonal and very numerous. Upon the whole, we are disposed to consider that Milne-Edwards and Haime were correct in regarding *H. subtubulata*, M'Coy, as a synonym of the present species; though, for reasons previously given, we keep the latter distinct in the meanwhile. The Upper Silurian, *H. micropora*, Eichw., has calices in general smaller, and always more closely set, though it is otherwise nearly allied to this species; while *H. porosa*, Goldf., of the Devonian, has calices of decidedly larger size than in *H. Murchisoni*, but mostly less closely set, and having slightly exsert margins and strongly developed septa. Lastly, *H. tenuis*, Bill., from the Upper Silurian of Anticosti, would seem to be separated sufficiently from the present form by its much more closely approximated large corallites.

4. Heliolites porosa, Goldf.—In this well-known Devon-

ian species the corallum is hemispherical, pyriform, globular, or irregular in shape, often attaining a large size. The large corallites are about 1-17th inch (= 2-3ds of a line) in diameter, and are separated by intervals of varying width, ranging from 1-100th inch up to 1-17th or 1-10th of an inch, or sometimes even more. The small corallites are polygonal, thin-walled, often with slightly thickened nodes at their angles of junction, in from one to six rows, their size varying, but averaging about 1-80th to 1-100th inch in diameter. The calices of the large corallites are approximately circular, slightly exsert, with remarkably well-defined crenulated walls. The septa are twelve in number, very well developed, but not reaching the centre. The tabulæ of the large corallites are horizontal, and from 1-20th to 1-10th inch apart; those of the small tubes are likewise straight, and are from 1-40th to 1-60th inch apart.

The above brief description is taken from examples of this species from the Devonian of the Eifel, and the minute measurements are from thin sections. We have, however, examined specimens from the Devonian of Devonshire and of Australia, and we find them to differ in no material respect from the above.

H. porosa, Goldf., is perhaps most nearly allied to the Upper Silurian *H. Murchisoni*, E. and H.; but the large tubes are, on the whole, very decidedly larger, and less closely disposed, while the calices project somewhat, and the septa are very well developed. From *H. interstincta*, Linn., the present species is distinguished chiefly by the much wider and more variable intervals which separate the large corallites.

5. Heliolites micropora, Eichw. (Leth. Ross., p. 454, Pl. XXV., fig. 7).—The only example of this species which we have seen is one kindly given to us by Dr Lindström, from the Upper Silurian of Gotland. This we have submitted to a careful microscopic examination, with the following results: The corallum is in the form of an irregular lobate mass, the upper, as well as most of the under, surface of which is covered by the calices. The large corallites are rather more than 1-30th

inch in diameter (between one-half and one-third line), and are separated by intervals of from 1-50th to 1-30th inch, or rarely 1-20th inch. The small corallites are polygonal, thin-walled, in from three to five rows. The calices of the large tubes are not at all prominent, with twelve very short and delicate septa. The tabulæ of the large corallites are horizontal, about 1-25th inch apart; those of the small tubes being also horizontal, and about 1-50th inch apart.

There can be no doubt as to the close relationship which subsists between this form and the *H. Murchisoni* of Edwards and Haime. Upon the whole, however, the large corallites of *H. micropora*, Eichw., are decidedly and uniformly more closely set than in *H. Murchisoni*, and they are separated by a smaller number of small corallites. The septa in the former species are, moreover, better developed, and the tabulæ decidedly wider apart, than in *H. Murchisoni*, while its corallum is expanded and lobate, and not discoid. Nevertheless, it is questionable if these two forms are more than mere variations of a single species, or if their differences are not due to age or locality.

6. Heliolites pyriformis, Hall. — The name of *H. pyriformis* was given by Hall to a species of this genus from the Upper Silurian deposits of North America (Pal. N. Y., vol. iii. p. 133, Pl. XXXVI. A., fig. 1, 1852), which was regarded by Edwards and Haime as identical with *H. interstincta*, Linn. (Brit. Foss. Cor., p. 249). Recently, however, Dr Rominger (Foss. Cor. of Michigan, p. 10, Pl. I., fig. 2) has described specimens from the Niagara Limestone of Drummond Island to which he gives the name of *H. pyriformis*, Hall, and to which he ascribes the following characters: Corallum subglobular in form, the large corallites being "about one millimeter" in width, separated by intervals of similar or somewhat greater breadth. Small corallites minute and numerous; the septa of the large tubes spinulose, arranged in twelve cycles, fused with the tabulæ into a cellular mass.

Accepting the accuracy of Rominger's description, and the

correctness of his reference of his specimens to *H. pyriformis*, Hall, it seems clear that this form cannot be regarded as identical with *H. interstincta*, Linn. At any rate, it possesses large corallites of a decidedly smaller size, while its septa, if really spiniform, differ materially from the lamellar septa of the latter species.

7. Heliolites tenuis, Billings (Can. Nat., ser. 2, vol. ii. p. 248, and Cat. Sil. Foss., Anticosti, p. 32).—The late Mr Billings has given this name to a species of *Heliolites* from the Upper Silurian rocks of Anticosti, the general form and dimensions of the corallum of which are not stated. The large corallites are said to be mostly a little less than half a line in diameter, and a quarter of a line distant from one another, with "excessively thin and rarely distinguishable" walls. The small corallites are minute and polygonal. Mr Billings says that this species may, perhaps, be a *Protaræa*, but as we have seen no specimens which we could refer to it, and as no figures accompany the brief published description, we can offer no opinion upon its affinities.

8. Heliolites parvistella, F. Roemer (Sil. Fauna von Sadewitz, p. 25, Pl. IV., figs. 6 *a*, 6 *b*, 1861).—The corallum of this form is large and globular, or hemispheric in form. The large corallites are from 1-6th to 1-4th line in diameter, with almost superficial calices, and with no clear walls, the interspaces between them being from one-third to one-half line. The small corallites are polygonal in shape, and are in eight or ten rows between any given pair of large tubes. The septa in the large corallites reach nearly to the centre of the visceral chamber. The species is from the Upper Silurian.

We have not had access to any specimens of this singular form, and can add nothing to the above digest of its principal characters. It differs in some respects from the type of the genus, but, if rightly referred here, it is clearly distinct from all the other recorded species of *Heliolites*.

9. Heliolites megastoma, M'Coy (*Palæopora megastoma*, M'Coy, Brit. Pal. Foss., p. 16, Pl. I. C, figs. 4-4 *b*).—The speci-

mens upon which Professor M'Coy established this species seem to have been derived from the Coniston Limestone of the North of England, and there is room for considerable doubt as to whether they are really identical with the form which has been always recognised by this title by subsequent writers. We have no means at present of resolving this doubt, but such specimens of *H. megastoma* as we have seen from the Coniston Limestone are remarkable for their well-developed and spiniform septa, whereas the forms from the Wenlock Limestone usually known under this name have the septa quite rudimentary and lamellar. We subjoin here the principal characters of the species as derived from Upper Silurian examples.

Corallum subhemispheric or globular; the large corallites circular, with crenulated walls, and rudimentary or almost obsolete septa. Calices not exsert. Large corallites from 1-10th to 1-12th inch in diameter (M'Coy says from one and a half to nearly two lines), separated by intervals which usually vary from 1-20th to 1-12th of an inch. Small corallites in from two to six rows, from 1-50th to 1-60th inch in diameter. Tabulæ of the large tubes from 1-40th to 1-25th inch apart, those of the small tubes from 1-60th to 1-80th inch apart, in both sets of tubes straight and nearly horizontal.

This species is distinguished from *H. interstincta*, Linn., its nearest ally, by the greater size of the large corallites, and the smaller proportionate width of the interspaces occupied by the smaller tubes.

10. Heliolites placenta, Goldf. (*see* Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 219).—This species is described by Edwards and Haime as possessing a large, thin, subcircular corallum, which is covered inferiorly by a strong epitheca. The large corallites have very thin walls, are about one line in diameter, are nearly equidistant, and are separated by intervals of rather more than half a line. The septa are in twelve rows; and the small corallites are polygonal, and apparently between 1-70th and 1-80th inch in diameter.

This species is imperfectly known, and we are not acquainted

with any specimen of it. If it be really a *Heliolites*, it would appear to be sufficiently separated from the recorded species of the genus by the peculiar form of the corallum, and the large and close-set calices. The species is Devonian.

11. HELIOLITES SPARSUS, Billings (Can. Nat., ser. 2, vol. ii. p. 428, and Cat. Sil. Foss. of Anticosti, p. 31).—The large corallites in this species are said to vary from one-half to one line in diameter, and to be separated by interspaces of from one to three lines. The septa are greatly developed, and sometimes meet in the centre of the visceral chamber. The small corallites are stated to be sometimes traversed by straight tabulæ, but at other times to be occupied by vesicular tabulæ, both conditions being present in a single specimen. The examples of the species are from the Upper Silurian rocks of Anticosti.

This species is imperfectly defined, and we have seen no example of it, nor have any figures of it been published. Judging from the description given by Mr Billings, we should imagine it to be really a *Plasmopora*, since the occasional and partial presence of horizontal tabulæ in the smaller corallites is not altogether unknown in this genus, while no undoubted species of *Heliolites* has been shown to possess vesicular tabulæ in the small tubes.

12. HELIOLITES PLASMOPOROIDES, Eth. jun., and Nich. (Ann. and Mag. Nat. Hist., ser. 5, vol. iv. p. 225, Pl. XIV., figs. 2-2 *b*).—The corallum in this species is massive and subhemispherical; the large corallites are about 1-10th to 1-8th inch in diameter, and are separated by intervals of mostly about half a line. The septa are marginal and rudimentary. The small corallites are very irregular in form, mostly in a single row only between any given pair of large tubes, and they are crossed by numerous straight tabulæ of the type of these structures in *Heliolites* generally.

This species is from the Devonian deposits of Queensland, and is distinguished by its curious combination of the characters of *Heliolites* with those of *Plasmopora*. Thus, it resembles

Plasmopora in the circular or oval, closely approximated large corallites, and in the irregular form of the small tubes which separate these, while it agrees with *Heliolites* proper in the important structural character that the small corallites have distinct and well-developed walls, and possesses straight and horizontal, instead of vesicular, tabulæ.

13. Heliolites Daintreei, Eth. jun., and Nich. (Ann. and Mag. Nat. Hist., ser. 5, vol. iv. p. 224, Pl. XIV., figs. 3-3 *a*).—Corallum massive, discoidal, with a slightly convex upper surface, often attaining a large size. The large corallites from 1-16th to 1-12th inch in diameter, with intervals mostly less than their own diameter. Small corallites polygonal, thin-walled, generally in only two rows between any pair of large tubes. Calices deeply crenulated by the well-developed septa.

This species is from the Devonian of Queensland, Australia, and most nearly resembles *H. megastoma*, M'Coy, from which it differs in the greater development of the septa, and the generally smaller and more closely set large corallites, as well as in some other less important characters.

14. Heliolites dubia, Fr. Schmidt (Silur. Form. in Ehstland, p. 228).—Corallum like that of *Monticulipora petropolitana*, Pand., in form—*i. e.*, hemispherical or discoid, with a flat or concave base. Large corallites circular, with an extreme diameter of 1-48th of an inch (a quarter of a line), separated by excessively narrow interspaces, occupied by minute polygonal corallites. Septa rudimentary. Internal structure unknown.

The best description, and the only figures, of this species with which we are acquainted, is one given by Ferd. Roemer (Sil. Fauna von Sadewitz, p. 26, Pl. IV., figs. 5 *a*, 5 *b*). If truly a *Heliolites*, there can be no question as to its entire distinctness from all the other recorded species of the genus; but its minute structure is unknown, and it is quite possible that this curious form may turn out to be a *Propora*. It differs from the normal forms of *Heliolites* in its excessively close-set large corallites. The species is Silurian in its range.

15. Heliolites exiguus, Billings (Cat. Sil. Foss. of Anticosti,

p. 31, fig. 14).—Corallum massive, the large corallites about half a line in diameter, with intervals of rather more than half a line. Septa not determined. "Cœnenchyma minutely vesicular." Upper Silurian of Anticosti.

This species is described from a single specimen, and is only incompletely known. If it be truly a *Heliolites*, it will be difficult or impossible to separate it from *H. Murchisoni*, E. and H.; but if the "cœnenchyma" be really vesicular (a point upon which Mr Billings is not quite positive), then the species would have to be referred to *Plasmopora* or *Propora*.

16. Heliolites speciosus, Billings (Can. Nat., ser. 2, vol. ii. p. 426, and Cat. Sil. Foss. of Anticosti, p. 30, fig. 13).—Corallum massive, clavate, or pyriform. The large corallites rather more than one line in diameter, sometimes two lines; and usually about half a line apart, more or less, being sometimes in contact. Calices exsert, crenulated, with twelve rudimentary septa; the intervening surface being "covered with small rough tubercles." Interspaces between the large corallites occupied by "small vesicular cells, from one-sixth to one-third of a line in diameter." Upper Silurian, Anticosti.

In the absence of any sufficient information as to the internal structure of this form, it is useless to speculate as to its true position. If it be a *Heliolites*, it would doubtless be a good species, unless it proved to be identical with *H. macrostylus*, Hall. Judging, however, from the description given by Mr Billings, we should be disposed to think that it is really referable to *Plasmopora*, or, if the latter genus be ultimately retained, to *Lyellia*.

17. Heliolites affinis, Billings (Can. Nat., ser. 2, vol. ii. p. 427, and Cat. Sil. Foss. Anticosti, pp. 5 and 30, fig. 12).—Corallum globular, hemispherical, or pyriform, sometimes encrusting. The large corallites from one-half of a line to one line in diameter, in contact, or barely separate, with exsert calices. The small corallites ("cœnenchyma") rudimentary, vesicular. Septa in the large tubes rudimentary, twelve in number. Upper Silurian, Anticosti.

There can be no doubt that this is not a true species of *Heliolites*. Dr Lindström (Öfversigt af Kongl. Vetenskaps-Akad., Förhandl., 1873) refers the species to *Plasmopora*, and his opinion is founded upon specimens sent to him by Mr Billings. Judging from the description and figure given by Mr Billings, we should be disposed to regard it as belonging to that section of *Plasmopora* separated by the name of *Propora*, E. and H., and we should doubt if it were specifically separable from the well-known *P. tubulata*, Lonsd.

18. Heliolites macrostylus, Hall (Pal. N. Y., vol. ii. p. 135, Pl. XXXVI. A, fig. 2).—This form was originally described from the Upper Silurian (Niagara Limestone), but the description given offers no points upon which any conclusion as to the validity of the species could be founded. Milne-Edwards and Haime (Brit. Foss. Cor., p. 251) regard the species as a synonym of *H. megastoma*, M'Coy. The few specimens which we have seen (from the Niagara Limestone of Manitoulin Island, Ontario) are, unfortunately, much altered by silicification, and we cannot fully make out their internal structure; but they appear to us to differ from *H. megastoma*, M'Coy, in several points, and especially in their strongly developed septa. The small corallites, also, *appear* to have vesicular tabulæ, which would remove the species from *Heliolites* altogether, though on the existence of this character we cannot speak with absolute certainty. Recently, Dr Rominger (Foss. Cor. of Michigan, p. 14) has placed *H. macrostylus*, Hall, as a mere synonym of *Lyellia Americana*, E. and H., the type of the genus *Lyellia*. If this determination be accepted as correct, then it will become a question if there be any character of generic value by which *Lyellia*, E. and H., could be separated from *Plasmopora*, E. and H. The definition of *Lyellia* given by Rominger (*loc. cit.*) certainly gives no indication of such a character; but in the absence of sufficient material, we refrain from pronouncing any positive opinion upon this point.

19. Heliolites Grayi, Edw. and Haime (Pol. Foss. des Terr. Pal., p. 217).—Corallum dendroid, of flattened branches,

or sublobate, the large corallites from one-third to one-half line in diameter, with variable interspaces (most usually from one-third to one-half line). The small corallites are irregular in shape, thick-walled, usually in four or five rows between each pair of large corallites. Septa thick and unequal, extending far into the visceral chambers.

This species occurs in the Wenlock Limestone, and we have described it as occurring in the Lower Silurian (Craighead Limestone) of the Girvan area (*see* Fasciculus, I., p. 58). It is sufficiently distinguished from all the ordinary species of *Heliolites* by its mode of growth; while it differs from *H. inordinata*, Lonsd.—its nearest ally—in the flattened form and greater size of its branches, and its generally smaller and more closely set large corallites.

20. Heliolites inordinata, Lonsd. (Sil. Syst., p. 687, Pl. XVI., *bis*. fig. 12).—Corallum dendroid, composed of slender, rounded branches, from one to one and a half line in diameter. Large corallites, half a line in diameter, placed at variable intervals. Small corallites polygonal, irregular in shape. Septa twelve, unequal.

We have not had the opportunity of examining examples of this species, and can give no details as to its minute structure. It appears to be sufficiently separated from *H. Grayi*, E. and H., by the fact that the corallum is composed of slender and rounded branches, while the large corallites are, upon the whole, larger in size than in the latter species, and also more irregularly distributed. It is a Lower Silurian form.

21. Heliolites (Palæopora) subtilis, M'Coy (Ann. and Mag. Nat. Hist., ser. 2, vol. vi., 1850; and Brit. Pal. Foss., p. 17). —This form is described by M'Coy as possessing a dendroid corallum, of cylindrical branches, usually from one and a half to two lines in diameter. The large corallites are "about one-sixth of a line in diameter, and a little more or less than their diameter apart." The small corallites are polygonal, "about thirty in the space of one line," or usually in five rows between any given pair of large tubes.

Milne-Edwards and Haime (Brit. Foss. Cor., p. 253), with some little doubt, identify *H. subtilis*, M'Coy, with the previously described *H. inordinata*, Lonsd. If, however, M'Coy's description of *H. subtilis* be accurate, then it cannot possibly be identical with Lonsdale's species, as the larger corallites are stated to be only one-sixth of a line in diameter, whereas they are half a line in diameter in *H. inordinata*. Similarly, the large corallites are much smaller than in *H. Grayi*, E. and H., the only other recorded species of *Heliolites* in which the corallum has a ramose habit of growth. In the absence of any direct knowledge of the original specimens upon which M'Coy founded his species, we should not, therefore, regard ourselves as justified in denying its validity. On the other hand, Prof. M'Coy gives no other locality for *H. subtilis* than Mulloch, near Girvan, where he states it to be "very common." The collections made by Mrs Gray from this region contain, however, absolutely no examples which we could possibly refer to *H. subtilis;* and when we consider the extent of these collections, and the great care and thoroughness with which they have been assembled, we can hardly avoid the conclusion that Prof. M'Coy must have been under some misapprehension as to the locality whence his specimens were derived.

Heliolites interstincta, Linn.

(Pl. XVI., figs. 1-4.)

Obs.—In the First Fasciculus of this work (p. 57), we noticed the occurrence of examples of this species from the Upper Silurian strata of Mulloch Hill and Penkill, near Girvan. Since the publication of this notice, as before remarked, we have had occasion to very carefully investigate the minute structure of many species of *Heliolites*, and particularly of *Heliolites interstincta*, as ordinarily understood. This species has usually been defined principally by the absolute and relative dimensions of the large corallites and of the intervals occupied by the small corallites, and, in a general way, all specimens agreeing in these

dimensions with *H. interstincta*, as defined by Edwards and Haime, would be unhesitatingly referred to this species. We have made a large series of thin sections of a number of such specimens, and with a view of bringing out the real characters of this species, we subjoin here brief notes on the structure of four examples from different localities, but all from strata of Upper Silurian age.

(1.) *A specimen from the Wenlock Limestone of Gotland* (kindly given us by Dr Lindström). — Corallum discoid, epithecate below, about two inches in diameter, and half an inch in height. Large corallites 1-17th inch (= about two-thirds of a line) in diameter; intervals between the large corallites 1-20th to 1-12th inch in diameter; small corallites, in from three to five rows, from 1-60th to 1-100th inch in diameter. The large calices are circular, not exsert, with slightly crenulated walls, the septa being very imperfectly developed, and having the form of twelve rudimentary marginal lamellæ (Pl. XVI., fig. 3). The small corallites thin-walled, polygonal. Tabulæ of large tubes (Pl. XVI., fig. 3 *a*) usually about 1-50th inch apart, but sometimes 1-100th inch apart, and, to some extent, coalescent. Tabulæ of small corallites from 1-80th to 1-100th inch apart, horizontal.

(2.) *Specimen from the Wenlock Limestone of Stoke-Edith.*— Corallum large and massive, imperfect, but about four inches in width, and over two inches in height. Large corallites 1-20th inch (or less than two-thirds of a line) in diameter; intervals between the large corallites from 1-30th to 1-20th inch in diameter; small corallites in from three to five rows, from 1-60th to 1-90th inch in diameter. Large calices circular, not exsert, with slightly crenulated walls, and twelve marginal and quite rudimentary septal ridges (Pl. XVI., fig. 4). Small corallites polygonal, with horizontal tabulæ placed about 1-100th inch apart. Tabulæ of large corallites about 1-60th inch apart in general (Pl. XVI., fig. 4 *a*).

(3.) *A second specimen from the Wenlock Limestone of Dornington, Stoke-Edith.*—Corallum in the form of a large irregular

expansion, epithecate below. Large corallites from 1-17th to 1-18th inch in diameter; intervals between the large corallites varying from 1-50th to 1-17th inch, but averaging 1-30th inch in diameter; small corallites in three, four, or more rows, about 1-50th inch in diameter. Large calices circular, not exsert, with strongly folded and crenulated walls. Septa twelve in number, lamellar, strongly developed, extending far into the visceral chamber, and often uniting centrally into a loose and irregular trabecular axis or pseudo-columella (Pl. XVI., figs. 2-2 *b*). Small tubes polygonal, with horizontal tabulæ placed at intervals of from 1-80th to 1-120th inch apart. Tabulæ of large tubes from 1-60th to 1-120th inch apart.

(4.) *Specimen from the Upper Silurian of Woodland Point, Girvan*, (Pl. XVI., figs. 1-1 *b*).—Corallum pyriform (in some cases globular or hemispherical), of small size (average specimens are about one inch in height, and the same or less in greatest width). Large corallites 1-17th inch (about two-thirds of a line) in diameter; intervals between the large corallites from 1-30th to 1-15th inch in diameter; small corallites in from two to five rows, from 1-60th to 1-80th in diameter, irregularly polygonal in their shape. Large calices circular, not exsert, with crenulated and inflected walls. The septa, twelve in number, extending far into the visceral chamber, with partial and occasional traces of an actual central union. Tabulæ of large tubes from 1-20th to 1-60th inch apart, uniformly and deeply bent downwards in the centre of the visceral chamber, so as to be concave above. Tabulæ of the small corallites from 1-40th to 1-80th inch apart.

We have selected the above four specimens as excellent examples of the coral ordinarily known as *Heliolites interstincta*, Linn., to which they would unhesitatingly be referred by an examination of their external characters. They do not, in fact, differ from one another superficially—leaving their size and form out of consideration—except in trivial features, which may well be included within the limits of specific variation. In internal structure, however, they present certain differences, by

means of which they may be clearly divided into two groups, in accordance with the condition of the septa. To the first of these groups belong specimens 1 and 2, which may be regarded as types of an immense number of specimens from the Wenlock Limestone of Britain, and indeed of Europe generally. These specimens have the dimensions of the large tubes, and the other general characters of *H. interstincta*, Linn.; but their septa are quite rudimentary, being never more than mere marginal ridges, and being often recognisable only by the slight crenulations in the walls of the large corallites. On the other hand, specimen 3 is an example of another series of specimens, also very abundant in the Wenlock Limestone of Britain, and also with the general characters of *H. interstincta*, in which the septa are extremely well developed, and have the form of twelve strong lamellæ, which always extend for a long distance into the visceral chamber. Very commonly, the septa meet centrally, and give rise to a median reticulated or trabecular pseudo-columella. When this occurs, it is not uncommon to find this central reticulation in the large corallites so greatly developed, that tangential sections of the corallum appear under the microscope as if completely made up of cellular tissue, and the outlines of the large corallites can only be detected with great difficulty. In long sections, also, the central reticulation of the septa in the axis of the large tubes can readily be detected, and its appearances are very similar to those presented in vertical sections by the very similar reticulated pseudo-columella of *Streptelasma*. It should be added, that though well-preserved specimens demonstrate the existence of this central reticulation beyond the possibility of doubt, it is very common to find that in certain of the tubes, or in all of them, the delicate septa have been partially disintegrated or broken up, though the remains of the structure in question can always be detected.

It appears from the above, that among the specimens from the Wenlock Limestone which, from the dimensions of their tubes, the relative distance of their large corallites, and their

other general characters, would usually be included under the name of *H. interstincta*, Linn., there are really included two distinct groups. In the one of these groups the septa are marginal and quite rudimentary; in the other the septa are extremely well developed, and often anastomose centrally. In the latter, moreover, the large tubes are slightly smaller, and the intervals between them are decidedly narrower than in the first group, while the corallum is usually larger and more widely expanded. We have no means of finally deciding whether these two groups are merely composed of the varietal forms of a single species, or whether they are really distinct species; but they differ from one another more fundamentally than is usual in the species of *Heliolites*, and we should be inclined to separate them by titles of at least varietal value, if we had any means of ascertaining which was the original type of *Heliolites interstincta*, Linn. On this point, we have nothing to guide us but the statement of Milne-Edwards and Haime (Pol. Foss. des Terr. Pal., p. 214) that the septa in *H. interstincta* are "assez bien développées," from which we should conclude that it is the forms of the second of these groups which these authors had in view in their description of this species.

Finally, we have to briefly notice the specimens from Woodland Point, Girvan, of which we have above given a description from a typical example. Mrs Gray's recent collections from Girvan, comprise a number of specimens from this locality, which agree with one another in their small size and pyriform or subglobular shape, and which have all the general characters of *H. interstincta*. As regards the condition of the septa, these specimens belong upon the whole to the second group of forms which we have seen to be included under the head of *H. interstincta*. The septa, namely, are exceedingly well developed, and always extend to near the axis of the visceral chamber. There are, however, only imperfect and not universal traces of a central reticulation formed by the septa; the small tubes, though polygonal, are not so

geometric or regular in form as is usual in *H. interstincta;* and, so far as we have observed, there is the constant feature that the tabulæ of the large corallites are very deeply concave or bent downwards in the axis of the visceral chamber. It would not appear, however, that these differences alone should outweigh the general points of agreement between these specimens and the ordinary examples of *H. interstincta* from the Wenlock Limestone.

Formation and Locality.—Not unfrequent in a greenish-grey mudstone, of Upper Silurian age, from Woodland Point, near Girvan. (Gray Collection.)

Heliolites ? parasitica, Nich. and Eth. jun. (*sp. nov.*)

(Pl. XVI., figs. 5-5 *b*.)

Spec. char.—Corallum in the form of a thin parasitic crust, completely enveloping the shells of Gasteropods, and consisting of a single layer of corallites, from 1-24th to 1-15th inch in thickness. The large corallites vary from 1-20th to 1-18th of an inch in diameter, and are separated by intervals of from 1-50th to 1-70th inch or less. When the interspaces are below 1-70th of an inch in width, then the large corallites are in actual contact; when above this, the latter are separated by a single row of small corallites, which may become doubled at the angles of junction of the larger tubes. Large corallites, with about twelve triangular, or apparently trabecular septa, which have broad bases, and extend inwards to about a half of the distance between the wall and the centre of the visceral chamber. Small corallites thick-walled, irregular in shape, destitute of septa. In vertical sections no tabulæ can be detected, but the entire colony seems to be formed simply of a loosely trabecular or reticulate sclerenchyma, and the calices of the large corallites seem to be quite superficial.

Obs.—We have little to add to the above brief specific diagnosis of this curious coral, of which we have a number of speci-

mens from the "Gray Collection," and which appears to be quite constant in its habit and mode of growth. It occurs both as thin and well-preserved crusts, covering the exterior of the shells of Gasteropods, and also as *casts* lining the hollows left by the removal of such shells. We have never seen it growing upon any other organisms than spiral Gasteropods, and we have observed no specimens in which the characters of the *surface*—owing to the adherent matrix—could be examined.

We know of no species of *Heliolites* with which it is necessary to compare this, its peculiar habit, the trabecular or reticulate structure of the corallum, and the apparent absence of tabulæ, removing it widely from all the ordinary forms of this genus. It most closely resembles, in habit and general appearance, the parasitic *Protaræa vetusta*, Hall, of the Lower Silurian, from which it is separated by the undoubted possession of a set of small corallites intervening between the larger tubes. Owing to the tenuity of the corallum, and also to its being invariably attached to curved surfaces, it is very difficult to prepare satisfactory thin sections, and especially sections tangential to the surface. Tangential sections (Pl. XVI., fig. 5 *a*) would show it to be a *Heliolites*, with a remarkably ill developed series of small corallites. These sections also show that the large tubes are provided with septa, which are wanting in the small tubes. In vertical sections (Pl. XVI., fig. 5 *b*), the structure of the corallum seems to be simply reticulate, no distinction can be observed between the larger and smaller corallites save just at and below the surface, and no tabulæ can be detected. The absence of these structures may, however, be simply due to the extreme shortness of the corallites. There is also the peculiar feature that in all the sections the entire corallum seems to be composed of a loosely compacted and minutely porous sclerenchyma. In casts of the surface of the corallum, as seen in the hollows left by the removal of the shell upon which the colony grew, the large septate corallites, and the comparatively few small corallites intervening between these, can be recognised with the greatest distinctness.

Loc. and Horizon.—Not uncommon at Mulloch Hill, Girvan. (Gray Collection.)

Heliolites foliacea, Nich. and Eth. jun. (*sp. nov.*)

(Pl. XVI., fig. 6, and Pl. XVII., figs. 1-1 *b*.)

Spec. char.—Corallum in the form of thin, extended, undulated, sometimes folded, but apparently non-parasitic laminæ, which often have a considerable horizontal extension, and which vary from a fifteenth to about an eighth of an inch in thickness. Under surface not observed, but apparently epithecate. Large corallites about 1-24th of an inch in diameter, circular, with very slightly exsert calices, separated by intervals which vary from 1-50th to 1-24th of an inch, and are usually about the latter measurement. Small corallites numerous, with excessively thickened walls, and very contracted apertures, in from three to five or more rows. Septa in the large tubes broad and triangular, about twelve in number, extending inwards about one-third or one-half of the distance between the wall and the centre of the visceral chamber, wanting in the small tubes. In vertical sections, the distinction between the large and small corallites cannot be clearly made out, owing to the thickening of the tissues beneath the immediate surface by sclerenchymatous deposit, and also to mineralisation. The walls of the small tubes can, however, be seen to be excessively thick, and their cavities can be observed, under favourable circumstances, to be crossed by well-marked horizontal tabulæ.

Obs.—No species of *Heliolites* hitherto recorded is at all closely comparable with this. In its internal structure, and in the dimensions of the large corallites, and of the interspaces between these, the present form approaches more nearly to *H. Grayi*, E. and H., than to any other described form; but it differs from this, among other characters, by its peculiar mode of growth. Thus *H. Grayi*, E. and H., presents itself in the form of flattened or sublobate branches; whereas *H. foliacea*, nobis, has invariably the quite unique form, in this genus, of

large undulated laminæ, averaging about one line in thickness. The under surface, owing to the uniformly adherent matrix, cannot be observed; but there is no evidence whatever of the corallum having been parasitically attached to foreign bodies (except, doubtless, at some one point), and the general inferior surface would seem to be quite free, and probably covered with an epitheca. From all other species of the genus, save *H. Grayi*, E. and H., the present form is distinguished not only by its mode of growth, but equally by the excessively thickened walls of the small corallites (Pl. XVII., fig. 1 *a*). The result of this is that the visceral chambers of the small tubes appear in tangential sections merely as small round or oval apertures. The surface is often very well preserved (Pl. XVI., fig. 1); and an examination of this leaves no doubt as to the propriety of referring the species to *Heliolites*. In thin vertical sections (Pl. XVII., fig. 1 *b*) the internal structure can often be made out with difficulty, or not at all, and the large corallites cannot be separated from the small ones. This is apparently due partly to mineralisation, and partly to the secondary filling-up of the visceral chambers, as well as, to some extent, to the shortness of the corallites. From *H.? parasitica*, nobis, the present species is distinguished by its non-parasitic habit, the extensive development of the small corallites, and the fact that the general tissue of the corallum is not openly reticulate, but is regularly tubular.

Loc. and Horizon.—Apparently not very rare, in the Upper Silurian Mudstones of Woodland Point, Girvan. (Gray Collection.) All the specimens observed are more or less fragmentary, but the largest measured over three inches in length by about two inches in width; and its horizontal expansion would be much more than these measurements would indicate, as it is much folded upon itself.

Genus Plasmopora, Edwards and Haime, 1849.

(Compt. Rend., t. xxix. p. 262.)

Gen. char.—"Corallum discoidal when young, but becoming hemispherical or spheroidal when adult, its lower surface covered by a concentrically striated epitheca, while the upper surface carries the calices. Corallites in complete contact throughout, divisible into two distinct series. The larger tubes are comparatively few in number, and possess twelve lamellar septa, formed by infoldings of the wall, and extending but a short distance into the visceral chamber; while they are crossed by horizontal, complete, and comparatively remote tabulæ. The smaller tubes are devoid of septa, are comparatively irregular in form, and only possess distinctly differentiated walls when young. In their adult state their walls become amalgamated with the convex and anastomosing tabulæ by which their cavities are intersected, in such a manner that they can no longer be recognised as distinct structures, and the interspaces between the larger corallites become filled up with a loose tissue composed of irregular lenticular vesicles." (Nicholson, Pal. Tabulate Cor., p. 245.)

Obs.—The above definition may be taken as adequately characterising the species of *Plasmopora* proper, in the sense in which the genus was understood by Milne-Edwards and Haime. It has, however, been pointed out by Dr Lindström (Ann. Nat. Hist., ser. 4, vol. xviii. p. 16), as well as by one of ourselves (*loc. cit.*, p. 247), that the genus *Propora*, E. and H., can hardly be considered as separable from *Plasmopora* by any characters of a truly generic value. The recent collections made by Mrs Gray from the Girvan area have likewise brought to light a number of excellently preserved specimens of a new species of *Pinacopora*, nobis, the examination of which has led us to believe that this genus also is in reality very closely allied to *Plasmopora*, or rather to *Propora*. Upon

the whole, therefore, we are inclined to think that we may regard *Propora*, E. and H., and *Pinacopora*, nobis, as subgenera, or sections, of *Plasmopora*, E. and H., sufficiently distinct from the type-forms of this last to deservedly retain their special designations, but nevertheless not entitled, from a theoretical point of view, to take rank as independent genera. We propose, therefore, to define *Plasmopora*, and its sections *Propora* and *Pinacopora*, as follows :—

1. Plasmopora, E. and H.—Corallum discoid when young, hemispheric, subglobular, or pyriform in shape when adult. Large corallites with walls folded to correspond with a series of well-developed septa, which may be lamellar, or may be composed of vertical rows of closely approximated, upwardly directed spinules. Small corallites abundantly developed, separating the large tubes to a considerable distance from one another, and mostly in several (two to five) rows between any given pair of large corallites. Walls of the small corallites imperfect or obsolete, their tabulæ coalescing to form a vesicular tissue of lenticular cells. Calices not elevated above the general surface, in typical forms of the group, but in some cases distinctly exsert.

2. Propora, E. and H.—Corallum discoidal, hemispherical, or irregularly pyriform, or spheroidal. Large corallites circular, with comparatively ill developed septa, which are sometimes quite obsolete. The large tubes are close-set, much more nearly approximated than in *Plasmopora* proper, there being a corresponding diminution in the number of the small corallites. Usually only one row, rarely two rows, of small corallites between any given pair of large tubes. Walls of the small corallites incomplete or obsolete, their tabulæ anastomosing to form a vesicular tissue of lenticular cells. The calices, as a rule, more or less exsert.

3. Pinacopora, Nich. and Eth. jun. — Corallum free, discoid or coin-shaped, very thin, epithecate below. Corallites excessively short; the large tubes with rudimentary or marginal septa, very closely arranged, with rarely, and only par-

tially, more than a single row of small tubes between any given pair of the former. Small corallites sometimes with complete walls and horizontal tabulæ, sometimes with more or less extensively obsolete walls, and with the tabulæ coalescent and giving rise to a vesicular tissue of lenticular cells. Calices not exsert.

Speaking in a general way, the species of *Plasmopora* proper are distinguished by the comparative abundance of the small corallites and the correspondingly wide intervals which separate the large tubes; by the strongly folded walls and well-developed septa of the larger corallites; and by the fact that the large calices are, typically, not exsert. The species of *Propora*, again, are recognised by their exsert calices; by the comparatively close-set corallites, and the correspondingly limited development of the small tubes; and by the fact that the septa are very short or obsolete, and the walls of the large tubes only faintly crenulated. Lastly, the species of *Pinacopora* are distinguished by the extraordinarily thin leaf-like corallum and the corresponding shortness of the corallites, the large tubes being close-set and with marginal septa, but wanting the exsert calices of *Propora;* while the small corallites may or may not possess vesicular tabulæ, these structures being in the type-species horizontal.

If typical examples of these three groups be selected, they can be distinguished from one another with the greatest ease, and they might with good reason be regarded as really representing three sections of generic value. It must be admitted, however, that there are forms which, with the exsert calices of *Propora*, possess the comparatively numerous small tubes and the well-developed septa of *Plasmopora* proper, and which might thus indifferently be placed under either of these sections; while we have now to describe a new species of *Pinacopora*, which, with the general features of this section, exhibits a more or less completely vesicular condition of the tabulæ of the smaller corallites, and thus closely approximates to the type of *Propora*.

The richly fossiliferous beds of Woodland Point, near Girvan, have yielded to the recent researches of Mrs Gray a new species of each of these three sections, which we shall now proceed to describe. In so doing, however, we shall have occasion to refer at some length to the structure of previously known forms of this group, which we have had occasion to examine minutely during the course of the present inquiry; and we take this opportunity, also, of appending a description of an extra-limital species of *Plasmopora*, which appears to be new, and the structure of which may be usefully compared with that of the other species here described.

Plasmopora Girvanensis, Nich. and Eth. jun. (*sp. nov.*)

(Pl. XVII., figs. 2-2 *b*.)

Spec. char. — Corallum pyriform or clavate in shape, the largest specimen examined having a height of about two inches, by a width at the top of an inch and a half. Large corallites close-set, with circular or ovate, very slightly exsert calices, from 1-10th to 1-13th of an inch in diameter, separated by intervals of from 1-20th to 1-12th of an inch in diameter, the widest intervals corresponding with the vertical axis of the corallum. The walls of the large corallites are thick, very strongly crenulated, and furnished internally with strong upwardly directed spiniform septa arranged in vertical rows, and having their chambers crossed by strong horizontal tabulæ at intervals of from 1-20th to 1-30th inch. The small corallites of the colony are exceedingly irregular in shape and size, from one to three rows existing between any neighbouring pair of large tubes. Their walls, also, are imperfectly developed, and the tabulæ are convex, and anastomose laterally, so as to give rise to a series of lenticular vesicles occupying the interspaces between the large tubes.

Obs.—When we come to compare the present form with the previously described species of *Plasmopora*, we find that it is readily separated from the *P. petaliformis*, Lonsd., by the

generally larger size of the large corallites, and by the much smaller width of the intervals occupied by the small tubes. Thus, in transverse sections of the latter species (fig. 8, A) the large corallites are seen to be usually about a line in diameter, sometimes rather less; while they are separated by intervals of from one to as much as two lines. On the other hand, in the present species, the large tubes are separated by intervals usually considerably less than their own diameter;

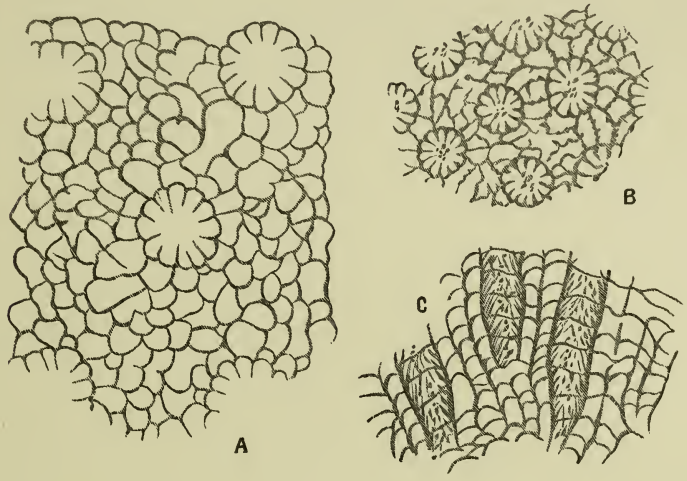

Fig. 8.—A, Transverse section of a specimen of *Plasmopora petaliformis*, Lonsd., from the Wenlock Limestone of Gotland, enlarged five times. B, Transverse section of *Plasmopora scita*, E. and H., from the Wenlock Limestone of Gotland, enlarged five times. C, Vertical section of the same specimen, similarly enlarged.

and there is the additional character that the small tubes are more irregular, and proportionately much larger than in *P. petaliformis.*

A microscopic examination, again, of *Plasmopora scita*, E. and H., shows that the large corallites (fig. 8, B) are circular or oval in shape, about 1-20th inch in diameter, and separated by intervals of from 1-30th to 1-60th inch. The large tubes, further, have well-developed crenulated walls, with twelve rows of strong septal spines, which have a marked upward direction, and extend to near the centre of the visceral chamber. The small corallites have imperfect walls, and form

irregular angular cells between the large tubes. The tabulæ of the large tubes (fig. 8, C) are complete and horizontal, while those of the small tubes are convex and commonly anastomose with one another, though this anastomosis does not take place to the extent of completely obliterating the walls of the small corallites. Upon the whole, *P. scita*, E. and H., is at once separated from *P. Girvanensis*, nobis, by the much smaller size of the large corallites.

Plasmopora follis, E. and H., and *P. micropora*, Goldf., are unknown to us, so far as microscopical examination goes; but the small size of the large corallites in both species is sufficient, of itself, to distinguish them from *P. Girvanensis*. The *Heliolites affinis* of Billings, from the Lower Silurian of Anticosti, is stated (Cat. Foss. Anticosti, p. 5, fig. 12) to have a vesicular "cœnenchyma;" and Lindström is therefore probably correct (Förteckning på svenska undersiluriska koraller; Öfversigt af Kongl. Vetenskaps-Akad. Förhandl., 1873) when he refers it to the genus *Plasmopora*. It is, however, sufficiently distinguished from the species now under consideration by the fact that the large corallites are mostly only about two-thirds of a line in diameter, and are "in contact with one another or barely separate" (Billings). Lindström is also probably correct (*loc. cit.*) in referring the *Propora conferta* of Edwards and Haime (Pol. Foss. des Terr. Pal., p. 225) to the genus *Plasmopora;* but this form, likewise, is readily distinguished from *P. Girvanensis* by the smaller size of the large corallites, and their much closer approximation to one another.

A closer resemblance, on the other hand, exists between *Plasmopora Girvanensis*, nobis, and the *Lyellia Americana*, E. and H. (? *Heliolites macrostylus*, Hall), of the Upper Silurian of North America. The few specimens, however, which we possess of this latter form are so highly silicified as to render it impossible to make out their minute structure; and we are therefore unable to say how far the general external likeness between these two forms may, or may not, be founded upon a real agreement in their internal conformation.

Loc. and Horizon. — In the Upper Silurian mudstone of Woodland Point, near Girvan. Also in the mudstones of Penkill, near Girvan. (Gray Collection.)

Plasmopora exserta, Nich. and Eth. jun.

(Pl. XVII., figs. 4, 4 *a*.)

Spec. char.—Corallum in the only specimen examined, forming a thin circular expansion with a convex upper surface, about three inches in diameter, and about one-third of an inch in thickness; its under surface being unknown. The large tubes are circular, with crenulated walls, and markedly exsert calices, about 1-33d inch in diameter (rather over one-third of a line), and separated by intervals of from 1-15th to 1-30th inch. They are furnished with well-developed spiniform septa, arranged in twelve rows, having an upward direction, and extending a considerable distance inwards. The small corallites are irregularly polygonal in shape, often with imperfect walls, allowing of lateral communication, and mostly only in two rows between any given pair of large tubes. In long sections (Pl. XVII., fig. 4 *a*) the tabulæ of the large corallites are seen to be horizontal, from 1-30th to 1-20th inch apart; while the small tubes have their walls largely obsolete, their tabulæ being convex, and uniting with one another to give rise to a tissue of variably-sized lenticular vesicles.

Obs.—Though this species is properly an extra-limital one, we have introduced a short description of it here, in consequence of its exhibiting a curious union of the characters of *Plasmopora* proper and *Propora*. A mere external examination of its surface would have certainly led us to refer it to *Propora*, as it possesses conspicuously exsert calices to the larger tubes. On the other hand, an investigation of its internal structure shows that it possesses the strongly crenulated walls to the larger tubes and the well-developed septa of *Plasmopora;* while

the walls of the smaller corallites are never so completely obliterated by the anastomosis of the tabulæ as is the case in *Propora*; so that we have little hesitation in referring it to the former genus.

In whatever genus it be placed, however, its specific distinctness seems to be sufficiently established by its minute structure; and the only two forms which it need be compared with are *Plasmopora scita*, E. and H., and *P. follis*, E. and H. Both of the forms just mentioned have the calices of the larger tubes flush with the general surface, and both possess a pyriform or spheroidal corallum; while in both the large corallites are of a decidedly greater size than is the case in the present species. These characters appear to be constant, and they are sufficient to separate these forms of *Plasmopora* from the species now under consideration. Upon the supposition that it really belonged to *Propora*, the present species would be most nearly related to *P. Edwardsii*, nobis, to be subsequently described; but the latter differs materially in the proportions of its corallites, while the corallum is pyriform, and the tabulæ of the small tubes are so completely vesicular as to obliterate the walls, the septa being at the same time obsolete.

Loc. and Horizon.—In the Wenlock Limestone of Dudley. (*Coll.*, H. A. Nicholson.)

Genus Propora, Edw. and Haime, 1849.

(Comptes Rendus, xxix. p. 262.)

Propora Edwardsii, Nich. and Eth. jun.

(Pl. XVII., figs. 3-3 *b*.)

Spec. char.—Corallum pyriform or subglobular, an average specimen being about an inch in height and an inch and a half in greatest width. Upper surface convex or flat. Large corallites about 1-20th inch in diameter, circular, their calices very slightly exsert, separated by intervals of from 1-70th to 1-25th

inch, but mostly about 1-60th inch apart. The walls of the large corallites are not crenulated, and the septa are entirely obsolete; while the visceral chamber is crossed by deeply-concave complete tabulæ, placed at about 1-80th inch apart. The small corallites are mostly in a single row (rarely in a double row here and there) between the large tubes, and are irregular in shape and size, though mostly distinctly angular. The tabulæ of the small tubes are convex or nearly straight, often uniting with one another to give rise to a vesicular tissue of lenticular cells, which largely or entirely obliterates the walls of the tubes.

Obs.—That the present species is properly referred to *Propora*, as here restricted, is placed beyond a doubt by the proportionate reduction of the small corallites and their angular form, by the circular non-crenulated large corallites, and by the total absence of the septa. It is nearly allied, in its general form and structure, to the well-known *P. tubulata*, Lonsd.; but the latter (Pl. XVII., fig. 5) differs materially from *P. Edwardsii* in the proportions of its corallites, the large tubes being mostly about three-fourths of a line in diameter, while they are separated by intervals of from 1-100th to 1-70th inch. The large corallites of *P. Edwardsii* are thus decidedly smaller than in *P. tubulata*, and, at the same time, proportionately more distant. Moreover, the tabulæ of the large tubes of *P. Edwardsii* are deeply and uniformly concave; while those of the small tubes, though commonly vesicular, are sometimes horizontal, and leave the walls of the interstitial corallites unaffected, single specimens showing both these conditions in different parts.

We have named this species in honour of M. Milne-Edwards, to whose labours amongst the living and fossil corals palæontologists are so greatly indebted.

Loc. and Horizon.—In the Upper Silurian mudstones of Woodland Point, Girvan. (Gray Collection.)

Genus PINACOPORA, N. and E.

(See *Fasciculus I.* p. 52.)

Pinacopora Andersoni, Nich. and Eth. jun.

(Pl. XVII., fig. 6, and Pl. XVIII., figs. 1-1 *e*.)

Spec. char.—Corallum free, discoid, coin-shaped, with a convex upper and concave lower surface, the former carrying the calices, while the latter is covered by a concentrically striated epitheca. Large specimens have a diameter of over two inches, with a thickness centrally of three lines, while young examples are only six or seven lines in diameter, with a thickness in the centre of a line or more. The large corallites are arranged in regular diagonal lines, being about 1-18th inch in diameter, and separated by intervals of about 1-25th of an inch. Their walls are faintly crenulated, and there are rudimentary septa, while the visceral cavity is crossed by complete horizontal tabulæ, placed at about 1-40th inch apart. The tabulæ cease to be developed in the upper part of the tubes, so as to leave proportionately deep calices. The small corallites are angular, a single row existing between any given pair of the larger tubes, and they are tabulate up to close to their mouths, and therefore to a higher level than is the case in the large tubes. The tabulæ are numerous, sometimes horizontal, but at other times convex, and anastomosing so as to give rise to a vesicular tissue of lenticular cells.

Obs.—The present species is very nearly allied to the form which we described from the Mulloch beds near Girvan (Mon. Sil. Foss., Girvan, Fasc. I., p. 54) under the name of *P. Grayi*, of which it may ultimately prove to be only a well-marked variety. It agrees with *P. Grayi* entirely in the form of the corallum, in its general aspect, and in the arrangement and relations of the corallites. It attains, however, a much greater size, and a greater proportionate thickness, specimens of *P. Grayi* having only a thickness of about one line at a diameter of sixteen

lines, whereas the same thickness is reached in *P. Andersoni* at a diameter of six lines, and fully grown specimens of the latter may have a thickness of three lines or more. There is, further, a constant difference in the tabulation of the two forms, to which we feel constrained, in the meanwhile, to attach a specific value. In both forms alike, there is the peculiar feature that the smaller tubes are tabulate to a much higher level (*i. e.*, to a point much nearer the surface) than is the case with the large tubes; but with this agreement their tabulation is otherwise importantly different. Thus, in *P. Grayi* the large corallites are so short that there is only room below the deep calice for one, two, or three tabulæ; while the tabulæ in the small tubes, though more numerous, are always complete, and approximately horizontal. On the other hand, in *P. Andersoni* the length of the large corallites is sufficient to allow of the development of a considerable number of tabulæ; while the tabulæ of the smaller tubes, though sometimes horizontal, are generally convex, and anastomose to form as regular and complete a vesicular tissue as is seen in corresponding parts of the corallum in the species of *Propora* or *Plasmopora*. These differences in the form and disposition of the tabulæ will be at once evident by comparing Pl. III., figs. 3 *i*, 3 *e*, with Pl. XVIII., figs. 3 *d* and 3 *e;* and, as before said, they seem to be constant, and to be of specific value.

We have named the present species after the late Mr Thomas Anderson of Girvan, who was well known to Scotch geologists as having made extensive collections of the fossils of the Girvan area.

Loc. and Horizon.—Not uncommon in the Upper Silurian mudstones of Woodland Point, near Girvan. (Gray Collection.)

Genus Halysites, Fischer, 1813.

(Zoognosia, 3d ed., t. i. p. 387.)

Catenipora, Lamarck, Hist. des An. sans Vert., t. ii. p. 205, 1816.

Gen. char.—Corallum fasciculate and reticulate, composed of long tubular cylindrical corallites, which are placed side by side in intersecting and anastomosing laminæ or lines, any given corallite being united with its neighbours to the right and left along its whole length, and each lamina of the corallum consisting of no more than a single linear series of tubes. Each tube is enclosed in a strong imperforate wall, surrounded on its free sides by a thick epitheca; and there may be a distinct division of the corallites into two series of different sizes, in which case a single small tube is placed between each pair of the larger tubes. In other cases all the tubes are similar in size and structure. Septa may be wanting, and, when present, have the form of vertically disposed rows of spines, in cycles of twelve. The tabulæ are complete, horizontal, or slightly concave, not vesicular, the smaller corallites (when present) being much more closely tabulate than the larger ones.

Obs.—The general confirmation and external characters of the corallum in the genus *Halysites* are so closely similar in all the known forms of this type, that the determination of the different species is a matter of extreme difficulty. Hence some high authorities have admitted only one or two species; while others (such as Fischer and Eichwald) have considered quite a large number of forms to be so far distinct as to deserve separate specific names. In almost all cases, however, the older observers have based their determinations of the species of this genus upon such obvious external characters as the size of the individual corallites, or the dimensions of the meshes of the network formed by the anastomosis of the laminæ of the corallum; and it cannot be denied that these, in the nature of things, must be to a greater or less extent variable and uncer-

tain characters, and characters especially liable to vary with age. On the other hand, it has been shown that there are in some cases important structural differences between different specimens of *Halysites* which at first sight appear to be the same, these differences affecting in the first place the condition of the septa, and, in the second place, the comparative size of the corallites of any given individual, and the development or non-development of a special series of small corallites. Thus, in some forms (such as the typical examples of *H. escharoides*, Lam., fig. 9 A) there exists a well-developed series of spiniform septa, arranged in twelve cycles; whereas such septa are wanting in other types (such as the typical examples of *H. catenularia*, Linn., fig. 9 B). Again, in some forms, such

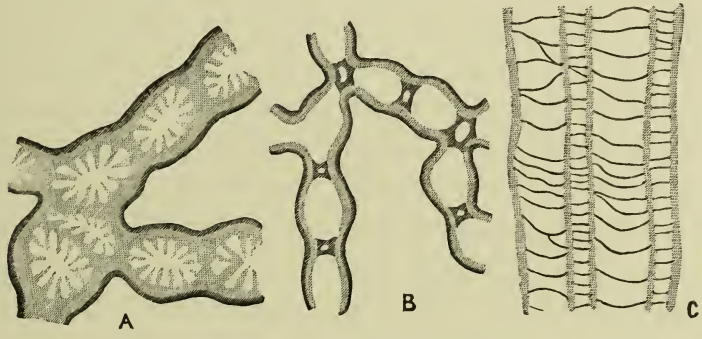

Fig. 9.—A, Transverse section of *Halysites escharoides*, Lam., from the Upper Silurian of Gotland, enlarged ten times, showing the spiniform septa, and the absence of a series of small corallites. B, Transverse section of *Halysites catenularia*, Linn., from the Wenlock Limestone of Dudley, enlarged five times, showing the absence of septa, and the presence of a series of small corallites. C, Vertical section of a few corallites of the last specimen, enlarged five times, showing the large and small corallites, and the difference in the tabulation of these.

as the typical *H. catenularia* of the Upper Silurian, there is the very important feature that there exists a special series of small corallites, which are more closely tabulate than the large tubes, and one of which is intercalated between each pair of the normal corallites (fig. 9, B and C). Other specimens, however, which in general appearance are not distinguishable from *H. catenularia*, do not exhibit upon minute examination these small corallites; while this series of tubes appears to

be also wanting uniformly in all specimens of the type of *H. escharoides*, Lam.

Taking the above almost inexplicable differences into consideration, we hardly think that it is at present possible to define with certainty the different species of the genus *Halysites*. A very vast mass of material will have to be submitted to microscopic examination before it will be possible for the observer to assert positively whether the above-mentioned important structural differences are *constant, and of specific value*, or whether they are not merely due to individual variation, or referable to other causes, such as the influence of sex, the temporary condition of the corallum as to the production of ova, or the actual dimorphism or polymorphism of the species. At any rate, it is clear that any attempt to finally determine the limits of any of the species of *Halysites* would be futile unless it were prefaced by an examination into the minute structure of the numerous forms of the genus which have been described under separate names by Fischer, Eichwald, and other palæontologists. In the absence of such an examination, it is useless to speculate as to how far differences in the size of the corallites or in the dimensions of the meshes of the corallum are associated with constant peculiarities in such important matters as the development of septal spines or the presence of a special series of small tubes; and it is therefore useless to attempt to define the species of the genus. Under these circumstances, we shall content ourselves with giving a description of the internal structure and general characters of three forms of *Halysites* which we have met with in the Girvan area, without referring these definitely to any previously named species, while at the same time noting the occurrence of what appears to be the normal form of *H. catenularia*, Linn.

Halysites catenularia, Linn.

Tubipora catenularia, Linné, Syst. Nat., ed. xii., p. 1270, 1767.
„ *catenulata*, Gmelin, Linné, Syst. Nat., ed. xiii., p. 3753, 1789.

[For the reasons above given, it is impossible to give any synonymy of this species which would be of any real value. We may say, however, that in the synonymy given in a previous portion of this work (Fasc. I., p. 49), we have united *H. escharoides*, Lam., with *H. catenularia*, Linn., but that we are now disposed to regard these forms as being specifically distinct; though a more extensive examination will be required before it will be possible to speak positively as to the relations between these forms.]

Obs.—In attempting to elucidate the real characters of this species we have, of course, been compelled to choose some form which we can reasonably suppose to be identical with the Linnean type; and we have selected the well-known Chain-coral of the Wenlock Limestone of Dudley, which palæontologists have always recognised as *H. catenularia*. This form, as previously shown by one of us (Pal. Tab. Corals, p. 228), is peculiar in apparently being constantly devoid of septal spines, and also in the fact that there exists a series of specially modified small corallites. One of these small tubes (fig. 9, B and C) is placed between every pair of the normal corallites, and not only is their size different, but they possess much more closely set tabulæ than is the case in the larger tubes. Milne-Edwards and Haime describe septal spines as present; but we have not been able to detect these in any of the thin sections we have prepared. The large corallites are oval, from about 1-20th to 1-15th inch in their long diameter; the small corallites are subquadrate, and about 1-60th inch in diameter. The tabulæ in both sets of corallites are complete, and mostly do not anastomose to any degree. The meshes formed of the laminæ of the corallum are mostly irregular and sinuous in outline, elongated, with a long diameter of from a quarter of an inch to an inch, and mostly having from three to six of the larger tubes in any one of the sides of the mesh.

Accepting the above as the principal characters of the Dud-

ley specimens of *H. catenularia*, Linn., we find among the many examples of this genus recently collected by Mrs Gray from the Upper Silurian rocks of Girvan, a few specimens which possess precisely similar features, and which we, therefore, refer to the same species. They agree, at any rate, with the Dudley examples not only in the size of the large corallites, and the general conformation of the corallum, but also in the much more important points that there appear to be no septa, while there is a well-developed series of small corallites separating the larger ones.

Form. and Loc.—Woodland Point, Girvan (in mudstones of Upper Silurian age). (Gray Collection.)

Halysites, sp.

(Pl. XVIII., fig. 2.)

Obs.—Among the specimens from the above-mentioned locality, we have various other examples, which resemble the Dudley form of *H. catenularia* in general characters, and especially in such superficial points as the size of the corallites and of the meshes of the corallum, but which differ in their internal structure to an important extent. The ordinary corallites are oval, with a long diameter in general of from 1-15th to 1-12th inch, thus rather exceeding in size the corallites of the Dudley form; and, as in the latter, no traces of septal spines can be detected. There is, however, the singular and important difference that in the examples now under consideration (Pl. XVIII., fig. 2) we find no indication whatever of the existence of a series of small corallites. On the contrary, the large tubes are placed directly against one another, without the intervention of any small tubes. The longitudinal section, therefore, simply exhibits the large, uniformly tabulate corallites.

How far the difference here noted can be regarded as of specific value, or to what extent it is possible that we have to deal simply with a difference due to dimorphism of a single species, is a question which we have no data to decide. Of

the reality of this difference there can be no doubt; and it seems impossible, in the meanwhile, to unite under the same specific name two forms presenting such a fundamental difference in their internal structure, however close their agreement may be in general form.

Form. and Loc.—Not uncommon in the Upper Silurian mudstones of Woodland Point, Girvan. (Gray Collection.)

Halysites, sp.

(Pl. XVIII., figs. 3, 3 *a*).

Obs.—Another form of *Halysites* which is very abundant at the locality just noted is very similar in its general configuration to *H. escharoides*, Lam., as usually understood. We have examined microscopically what we may regard as typical examples of *H. escharoides*, Lam., from the Wenlock Limestone of Gotland, and we find this type to be characterised by the possession of corallites of a single kind, interstitial small tubes being always absent; while there exists in all cases a well-developed system of spiniform septa, arranged in twelve vertical rows (fig. 9, A). The corallites are oval, and about 1-24th or 1-25th inch in their long diameter; and the meshes, which are formed by the laminæ of the corallum, are small (from one-fifth to one-third or more of an inch in long diameter), and have their sides formed of two, three, four, or five corallites.

The Girvan specimens, which have a general resemblance to the above, possess small uniformly-sized corallites, arranged in a close network, each side of any given mesh being formed by from one to three, four, or five corallites. There are no small tubes, and there are usually small septal spines, disposed in vertical rows and markedly directed upwards (Pl. XVIII., figs. 3, 3 *a*). In vertical sections (Pl. XVIII., fig. 3 *a*) these spines are cut across above their bases, and often look like so many rows of small pores in the wall. The septa, however, do not reach the same development as is seen in

typical examples of *H. escharoides*, Lam.; while the corallites are decidedly smaller, their long diameter being as a rule from 1-30th to 1-35th inch in length. The corallum has the general form characteristic of the species of *Halysites*, but is apparently usually of comparatively small size. Whether or not the differences above mentioned are sufficient to specifically separate this form from *H. escharoides*, Lam., and whether or not it is identical with any of the numerous species of the genus which have been described by Fischer and others, are questions which we have at present no means of deciding.

Loc. and Horizon.—Not uncommon in the Upper Silurian mudstones of Woodland Point, Girvan. (Gray Collection.)

Halysites, sp.

(Pl. XVIII., fig. 4.)

Obs.—In a fourth form of *Halysites* from the Girvan area, we have another type which in many respects resembles the *H. escharoides* of Lamarck, though it is in other respects peculiar. It resembles typical examples of *H. escharoides* from Gotland in the absence of small corallites, in the excellent development of twelve vertical rows of spiniform septa, and in the thickness of the walls of the corallites, resulting in a corresponding reduction in the calibre of the visceral chambers (Pl. XVIII., fig. 4). On the other hand, it much more closely resembles *H. catenularia*, Linn., in its general proportions, the corallites being from 1-18th to 1-12th inch in their long diameter, and the meshes formed by the laminæ of the corallum being comparatively large and elongated in form. As in the preceding cases, we must leave the specific position of this form at present an open question.

Loc. and Horizon.—In the cement-stones of Shalloch Mill, near Girvan. (*Coll.*, Charles Lapworth.) This form was noted, but not described or figured, in the First Fasciculus of this work, p. 49, under the name of *H. catenularia*, Linn.

Genus FAVOSITES, Lamarck.

(See *Fasciculus I.* p. 34.)

Favosites Mullochensis, Nich. and Eth. jun.

(Pl. XVIII., figs. 5-5 *b*.)

Favosites Mullochensis, Nich. and Eth. jun. Mon. Sil. Foss. Girvan, Fasc. I. p. 36, Pl. II., figs. 2-2 *b*, 1878.

Spec. char.—Corallum pyriform or more commonly spheroidal in shape, mostly from half an inch to an inch in diameter, but sometimes attaining a diameter of over three inches by a height of more than two inches. Corallites prismatic, often pentagonal, mostly with gently rounded angles, and with thin, often wavy, walls. The majority of the tubes are of large size, from half a line to about a line in diameter, but there always exist very much smaller corallites placed at the angles of junction of the larger tubes. Mural pores large, placed close to the angle formed by any two of the prismatic faces of the tubes, these angles being sharply undulated. Septa wanting. Tabulæ few, delicate, remote, from half a line to a line apart, often represented by short spines or laminæ springing from the undulated walls of the tubes.

Obs.—This species was originally described by us from a small number of examples from the Upper Silurian of Mulloch Hill, near Girvan (*loc. cit.*) Since that time Mrs Gray has obtained a very large number of specimens from the Upper Silurian mudstones of Woodland Point, Girvan; and we are therefore able not only to confirm our previously expressed opinion as to the specific distinctness of this form, but also to give some important additional information as to its internal structure. All our fresh specimens, both small and large, exhibit the mixture of small and large tubes, the rounded angles of the corallites, and the wavy walls, with the spiniform condition of many of the tabulæ, which first induced us to separate this form as a distinct species of *Favosites*. Not only do we find that the characters which we originally relied upon in

founding this species are constant; but we find the additional important point, that the mural pores have a position unusual among the species of *Favosites*, and only shared by very few forms. *F. Mullochensis*, in fact, agrees with *F. alveolaris*, Goldf., and *F. aspera*, D'Orb., in having the mural pores placed at, or close to, the angles of the prismatic corallites, instead of being situated, as is usual, on the flat faces of the same. The corallites (Pl. XVIII., fig. 5 *a*) have their walls strongly corrugated by transverse undulations, which are most marked at their angles, and the mural pores are placed close to the latter, and generally so as to alternate on the opposite sides of the line marking the angle. This peculiarity is, of itself, quite sufficient to separate *F. Mullochensis* from all the ordinary species of the genus, except the two forms above mentioned, in which a similar disposition of the mural pores is stated to obtain. Our species is, as a rule at any rate, of much smaller dimensions than either *F. alveolaris*, Goldf., or *F. aspera*, D'Orb., while its corallites are of decidedly smaller size, rarely exceeding three-fourths of a line in diameter. On the other hand, *F. alveolaris* and *F. aspera* are large and massive species of the genus, with a subplane upper surface, while the corallites are from a line and a quarter to a line and a half in diameter. It does not appear, also, that either of the above-mentioned species is distinguished by the same inequality in the size of the tubes as obtains in *F. Mullochensis*, and the form of their corallites is very regularly angular and prismatic. The marginal depressions of the tabulæ, which are stated to occur in *F. alveolaris* and *F. aspera*, and the number of which is supposed by Milne-Edwards and Haime to specifically separate these two forms, cannot be recognised in any of our specimens, though it is quite possible that they really exist. In any case, we cannot regard them as constituting a character of specific value.

Loc. and Horizon.—Abundant in the Upper Silurian mudstones of Woodland Point, Girvan. Also not uncommon in the dark-green Upper Silurian mudstones of Mulloch Hill, Girvan. (Gray Collection.)

SUPPLEMENT TO THE CRUSTACEA.

Order TRILOBITA.

(Continued from *Fasciculus II.* p. 207.)

Genus STAUROCEPHALUS, Barrande.

(See *Fasciculus I.* p. 117.)

Staurocephalus (?) *sp. ind.*

(Pl. XIX., fig. 3.)

Obs.—We can do little more than figure this fragmentary Trilobite, with a view to future identification, adopting the view of our friend Dr H. Woodward, and placing it provisionally in the above genus, with which it appears to have most in common. One of the chief peculiarities of the form appears to lie in the enlargement of the pleural spines after their extension beyond the lateral margins of the thorax. The cheeks are punctate, and each thoracic pleura is ornamented with a row of small but prominent granules.

Loc. and Horizon.—Whitehouse Bay, Ardmillan.

Genus CYCLOPYGE, Hawle and Corda, 1847.

Egle, Barrande, Notice Préliminaire, 1846, p. 34.
Cyclopyge, Hawle and Corda, Prodrom einer Monog. böh. Trilob., 1847, p. 64.
Æglina, Barrande, Syst. Sil. Bohême, 1852, i. p. 663.

Obs.—M. Barrande proposed the name *Egle* for the present group in 1846, apparently overlooking the fact that the term, either as *Egle* or *Ægle*, had already been used no less than four times—viz.,

Ægle, Oken, 1815, as a genus of Mollusca;
„ Hübner, 1816, „ „ Lepidoptera;
Egle, Robineau, 1830, „ „ Diptera;
Ægle, De Haan, 1835, „ „ Crustacea;

and once, at least, in Botany.

Hawle and Corda proposed their name in 1847; and as we are unaware that it had been made use of previous to this, it appears to us only reasonable and fair that it should be adopted in place of Barrande's still later name, *Æglina*, which has been usually preferred before Hawle and Corda's.

Cyclopyge rediviva, Barrande.

(Pl. XIX., fig. 4.)

Egle rediviva, Barr., Notice Prélim., 1846, p. 34.
Cyclopyge megacephala, Corda, Prodrom Mon. böhmischen Trilob., 1847, p. 64, t. 4, f. 32.
Æglina rediviva, Barr., Syst. Sil. Bohême, i. p. 665, t. 34, f. 3-13.
„ „ Bigsby, Thes. Siluricus, 1868, p. 35.

Spec. char.—Body subrectangular, rounded at both extremities; trilobation, to any extent, only visible on the thorax. Cephalic shield occupying nearly half the entire length of the body (the other portion being equally divided between the thorax and pygidium), truncated at the posterior margin, no subdivision into glabella and other parts. The grooves of the glabella are reduced to two, being thus represented by two faintly marked, hollow depressions, placed a little in advance of the posterior margin, and directed outwards.

Thorax of four segments; axis flatly convex, defined by strong axal furrows, wider than the side-lobes or pleuræ, attenuated posteriorly. Pleuræ somewhat bent down laterally, increasing in breadth in an inverse ratio to those of the axis—*i.e.*, the first succeeding the shield is the narrowest from side to side, and the last, next the pygidium, the broadest—in other words, the lateral lobes are attenuated towards the anterior instead of towards the posterior end of the body.

Pygidium semicircular, slightly convex; axis convex, of three rapidly attenuated subdivisions, extending backwards scarcely half the length of the whole tail; the two anterior segments are the broadest, the third or terminal one forming a somewhat more prominent body. Two faintly marked grooves are visible

on each of the lateral lobes of the tail, near to its anterior end, the remainder of the pygidium being smooth, devoid of grooves or furrows, and forming a gentle convex expansion. The united axes of the thorax and pygidium may be described as connate.

Obs.—This neat little Trilobite does not correspond with any one of the British species of *Cyclopyge*, but appears to possess in general the characters of *C. rediviva*, Barr. The eyes in our specimen and the lateral margins of the Trilobite are to a great extent hid by matrix, which from its nature does not admit of ready removal. The glabella grooves are only faintly visible, but the other characters are of too marked a nature to admit of much doubt of its identity. A metamorphosis has been shown to exist in *C. rediviva*, by M. Barrande, by which an increase in the number of thoracic somites takes place from four to six, and a corresponding diminution in those of the pygidium as maturity and full growth is approached. The form now described from Girvan corresponds to one of the younger stages found in Bohemia, in which there are four segments of the thorax developed,[1] but with the difference that in the Bohemian specimen the four-segmented thorax is accompanied by three subdivisions on the antero-lateral portions of the pygidium, whilst in the Girvan form the latter are only two in number.

The foregoing description is exclusively taken from the Girvan specimen, and is in no way a complete diagnosis of the species—this will be found in M. Barrande's work.

Loc. and Horizon.—Shore at Whitehouse, near Girvan, in a dark-grey, hackly-fractured, hard, calcareous shale, full of comminuted organic remains of Lower Silurian age. (Gray Collection.)

In Bohemia it is characteristic of the *Étage des Quartzites.* D (Faune seconde.)

As this is an additional locality, only lately collected from by Mrs Gray, and not given in the list of localities at the

[1] Barrande, *loc. cit.*, t. 34, f. 5.

beginning of this 'Monograph,' [1] we may state that it is situated between three and four miles south of Girvan.

Cyclopyge armata, Barrande.

(Pl. XIX., fig. 5-8.)

Æglina armata, Barr., Syst. Sil. Bohême, i., Suppl., p. 59; Suppl., Atlas, t. 3, f. 1-14, t. 15, f. 16-19.
„ „ Bigsby, Thes. Siluricus, 1868, p. 34.

Spec. char. — Glabella produced, oval, gently convex, continued anteriorly into a frontal spine; posterior margin straight, more or less truncated; surface bearing two pairs of similar horizontal, or very slightly arched, grooves, or shallow depressions; the more advanced pair are situated at a little less than half-way between the anterior and posterior margins, and nearer to the latter; the second, or posterior pair, lie between the latter and the posterior margin of the shield. Frontal spine in fully grown specimens somewhat elongated, small and tapering to a fine point, round in section; anterior portion of glabella and base of spine ornamented with fine anastomosing raised lines. Eyes of large size, cushion-shaped, uniting in front of and below the glabella to form one continuous convex optical organ. The epistome is of the usual form seen in this genus, ornamented with rather distant, occasionally anastomosing, fine ridges.

Obs.—Amongst the Girvan specimens we have not met with either a perfect head-shield, a thorax, or pygidium, although we do not doubt but that our figures will quite bear out the reference to Barrande's abnormal and peculiar species. We have before us five examples of the glabella; in no case are the eyes actually attached, but are chiefly preserved as fragments lying around and about the glabellæ. In two instances, also, more perfect examples with the epistome attached are present, quite corresponding with Barrande's description and figures, so that there can be little doubt we now possess this

[1] Fascic. I. p. 7.

additional and interesting species in our British rocks. The first identification of *C. armata* in the latter is due to Mrs Gray, who forwarded the specimens to us bearing this name attached to them.

It results from the form of the united eyes, that the epistome will be considerably lowered in position, or placed much further under the head than is usually the case in the other species of *Cyclopyge*, except perhaps in *C. mirabilis*, Forbes, to which it is most nearly allied, and in which the eyes are likewise united; but so far as present researches have gone, this species has not been shown to possess a frontal spine.

The knowledge acquired by M. Barrande of the structure of *Cyclopyge* enables us to subdivide the genus into three well-marked sections, which may at some future date be designated by distinct names. They are :—

a. *Cyclopyge* proper. Forms having the anterior margin of the glabella intact, *i.e.*, not produced into a frontal spine; eyes lateral in position to a greater or less extent, and not united in front; type, *C. rediviva*, Barr.

b. Forms with a similar anterior margin to the glabella; eyes much enlarged, extending forward, and united in front of the head to form one large optical organ; type, *C. mirabilis*, Forbes.

c. Forms with the anterior part of the glabella produced into a frontal spine, and the eyes as in section *b*; type, *C. armata*, Barr.

We shall look forward with much interest to further discoveries of *Cyclopyge* in the Girvan district. A foreshadowing, as it were, of this genus has at present only presented itself.

Loc. and Horizon.—Shore at Whitehouse, near Girvan, in a dark-grey, hackly-fractured, hard, calcareous shale, of Lower Silurian age. (Gray Collection.)

In Bohemia, *C. armata* occurs in the Band D 5, of the *Étage des Quartzites*, D, equivalent to portions of our Lower Llandovery, and Upper Caradoc rocks.

Genus, Trinucleus, Lhwyd.

(See *Fasciculus II.* p. 188.)

Trinucleus Macconochiei, Eth. jun., and Nich.

(Pl. XIX., fig. 9.)

Ampyx (?) *Macconochiei*, Eth. and Nich. This work, Fasciculus II. p. 183, t. 14, f. 1.

Obs.—After several attempts we have succeeded in obtaining a satisfactory cast in relief of this little Trilobite, which pretty conclusively proves our first impression of its generic affinities to be the correct one. Fig. 9, Pl. XIX., shows this cast in wax. It is unnecessary to redescribe it, as our former diagnosis remains good; we have only to add, as further information, that the constricted base of the glabella, with the deep pit-like furrows below it, taken in conjunction with the previously described features, clearly indicate *Trinucleus* as the proper genus, to which it should be referred. The only portion now wanting is the fringe. The ornamented condition of the head-shield is not abnormal, for it is met with in *T. ornatus*, Sternb.

The full number of thoracic somites in *Trinucleus* is six, but during the metamorphosis this number varies from none to six. In the present instance there are five segments, and we must therefore look upon this as an immature form, contrary to our former opinion, although it is difficult to believe this to be so, when, so far as our researches have at present gone, no other form of *Trinucleus* is met with in the Balcletchie beds.

The last-mentioned fact has determined us in retaining the above name in the meantime, leaving the solution of the difficulty for the future.

Trinucleus, *sp. ind.*

(Pl. XIX., fig. 10.)

Obs.—An additional *Trinucleus* has been found by Mrs Gray, but, unfortunately, in so fragmentary a state, that pre-

cise identification is nearly impossible. The glabella and one cheek are preserved, with a portion of the fringe. The latter, as in many species of *Trinucleus*, is more or less in the same plane with the remainder of the cephalic shield. Presuming this to be its normal condition in this instance, and not in any way due to contortion or displacement, we are at once provided with a very good character by which this fragment may be distinguished from *T. seticornis*, var. *Bucklandi*, to the fringe of which there is some resemblance in the form and arrangement of the perforations. The fringe itself in that species is, as we have before described it, much bent down, and, speaking generally, may be said to be placed at an angle of 85° with the plane of the head.

The glabella and cheek of the form now under description are covered with a well-defined reticulation.

Loc. and Horizon.—Shore at Whitehouse, near Girvan, in a dark-grey to blue, hackly-fractured, calcareous shale, probably of Lower Silurian age. (Gray Collection.)

Genus Dionide, Barrande, 1847.

Dione, Barrande, Notice Préliminaire, 1846, p. 33.
Dionide, „ N. Jahrbuch, 1847, heft. 4, p. 391.
Polytomurus, Corda, Prodrom Mon. böhmischen Trilob., 1847, p. 37.

Obs.—This very interesting genus is represented throughout the Silurian rocks of the world by a limited number of species, according to the enumeration given in Dr Bigsby's 'Thesaurus Siluricus.'[1] Of the four there recorded, only one is British, *D. atra*, Salter. The Silurian rocks of Girvan have yielded altogether five individuals of the genus *Dionide* to Mrs Gray's researches. The fragmentary and disconnected condition of these has caused us much perplexity in the limitation of species. On the one hand, we have before us the chance of combining under one name portions perhaps of two separate species, on the other, the almost equally fatal error of establishing unneces-

[1] P. 50.

sary species. This results from the absence of a sufficient number of specimens of each, by which it might be ascertained how far variation proceeds. As the object of the present work is not the mere coining of specific names, we shall content ourselves with creating only one name for the most perfect of the examples before us, and describing the others simply as indicated species, leaving for future observation the determination of how far the remains are related to one another.

Dionide Lapworthi, Eth. jun., and Nich. (*sp. nov.*)

(Pl. XX., fig. 1.)

Spec. char.—Body elongated, almost roundly wedge-shaped, attenuated posteriorly, dilated in front, its lateral margins appearing to have little convexity. Cephalic shield broadly semicircular, or broadly crescentiform, the convexity of the front margin more or less flattened, with the posterior margin truncate and almost straight. Glabella oval, probably convex, rounded in front, truncated behind, well defined from the remainder of the head-shield by the axal grooves, which indent the latter near the middle of the lateral margins of the glabella. From these indentations proceed oblique forwardly directed furrows; central protuberance of the glabella not visible. Neck-segment indistinctly preserved, but less in width than any of the thoracic somites. Cheeks not defined, but the remainder of the head-shield occupied by the flattened limb, entirely covered with small close non-perforating depressions or pits. The shield on each side of the glabella is crossed diagonally by two ridges or "eye-lines," from the genal angles to the indentations of the axal grooves at the sides of the glabella; each pair of ridges on leaving the genal angles are united, they then separate and diverge from one another, and ultimately again unite close under the glabella. Shield bordered by a strong thickened border, which terminates on each side at the genal angles; genal spines long and tapering, extending as far as the posterior termination of the body, and probably further.

Axis of the thorax slightly convex, tapering, a little less in width than the lateral lobes, well defined by the axal furrows; each ring consists of three more or less separated nodes, a central, and two lateral ones, the last being placed exactly at the outward terminations of the segment. Pleuræ broad, as measured from the anterior to the posterior margins; divided by an obliquely curved groove into two unequal portions, the anterior being the larger, and being punctate like the limb of the head-shield; the pleural grooves obliquely curved from before backwards.

Pygidium very long, attenuating to a more or less blunt point, and consisting of many coalesced rings or segments—sixteen at least, and perhaps more;—possessing all the characters of the thoracic somites, and becoming much deflected backwards as the anterior margin is receded from.

Obs.—The specimen of this remarkable form has undergone pressure in an oblique direction, giving to it the semblance of cleavage, although the absence of any such phenomenon in the matrix renders the latter explanation unlikely. The result of this oblique pressure has, in all probability, been to distort some of the characters, so that our description must, to a certain extent, be accepted as provisional, although we believe it to be correct in the main. One curious result of this oblique pressure has been to unduly expand the lateral portions of the cephalic shield, so that it projects beyond the boundaries of the thoracic segments, giving to the general outline a most peculiar appearance; at any rate, if this is the real condition of this Trilobite, it is a most abnormal one in the group.

It appears to us that, after allowing for this oblique pressure, we have in *D. Lapworthi* a *Dionide* in which the front margin of the head is broadly convex, the posterior margin truncate, and the body much elongated.

The four species of *Dionide* known to us are: *D. formosa*, Barr.,[1] from the Silurian rocks of Bohemia; *D. atra*, Salter,[2]

[1] Syst. Sil. Bohême, i. p. 641, t. 42, f. 24-28.
[2] Mem. Geol. Survey, iii. p. 321, t. 11 *a*, f. 9 and 9 *a*.

the British species; *D. euglypta*, Angelin,[1] from Sweden; and *D.* (?) *perplexa*, described by the late Mr Billings from the Anticosti Island group.[2]

From *D. formosa* our species is distinguished by its much more elongated body, more truncated posterior margin of the head, broader thoracic somites, and weaker genal spines. From *D. euglypta* the same characters will suffice for separation, except that here the general form of the body is more analogous to that of our species, whilst an additional point of departure presents itself in the absence of the cephalic diagonal ridges in Angelin's species, and in its very short spines. The pygidium is much nearer that of *D. Lapworthi* than is that of *D. formosa*. With a figure of *D.* (?) *perplexa* we are not acquainted, but, so far as an opinion can be formed from Billings's description, the two species are distinct.

Unfortunately *D. atra* is known only as a pygidium, and as in the case of *D. euglypta*, this portion of the body approaches that of our species more nearly than does that of *D. formosa*. The proportions taken from Salter's figure will not, however, permit us to include our form in the Welsh species, in the absence of any details of the head.

Our next figure (Pl. XX., fig. 2) represents a small (or portion of a small?) pygidium found in the same bed with *D. Lapworthi*, and possibly identical with it, since the direction and length of the pleural grooves in both specimens coincide; unfortunately, however, the lower portion of the tail of the latter has been injured. Fig. 2 (Pl. XX.) differs no more from the posterior portion of fig. 1, of the same plate, than does the isolated pygidium of *Dionide formosa* given by Barrande,[3] from that of his complete figure[4] of the same species. This pygidium is broader along the line of fracture from its anterior portion, now lost, than is that of *D. Lapworthi* at a corresponding point, measured from its posterior margin, and the axis is certainly narrower. This specimen is one of the debatable

[1] Pal. Suecica, t. 9, f. 6.
[2] Cat. Sil. Foss., Anticosti, p. 67.
[3] *Loc. cit.*, t. 42, f. 25.
[4] Ibid., f. 24.

forms which we must leave for future research to decide upon.

We have much pleasure in naming this species after our friend Mr Charles Lapworth, who has been long engaged in investigating the Silurian rocks of the Girvan area, and who, we believe, found the specimens.

Loc. and Horizon.—Whitehouse Bay, near Girvan, in a thin, dark-coloured, flaggy shale, of Lower Silurian age. (Gray Collection.)

Dionide, *sp. ind.* (*a.*)

Phacops truncato-caudatus, Eth. jun., and Nich. This work, Fasciculus I. p. 99, t. 7, f. 3 and 4 (*non.* Portlock).

Obs.—Misled by certain deceptive appearances, we described this Trilobite, in our First Fasciculus, under the above name. We are indebted to Mr Charles Lapworth for pointing out to us our mistake, and now repair our error.

It is without doubt a well-marked form of *Dionide*, and had the head been more fully preserved we should not have hesitated to apply a specific name to the specimens. Both the nodular axis, and the divided pleuræ are exceedingly well marked, the latter being almost twice the width of the thorax. The punctæ usually seen on the fore half of each pleura in *Dionide* are here replaced by vertical striæ or small ridges.

The pygidium is rather small, and consists of fourteen coalesced segments at least, with almost the same marked characters as are displayed by those of the thorax.

This form probably comes nearer to *Dionide formosa*, Barr., than any other of the Girvan species, although we believe it to be distinct. We hope further material may reach us eventually.

Loc. and Horizon.—Drummuck Quarry, neary Girvan. (Gray Collection.)

Dionide, *sp. ind.* (*b.*)

(Pl. XX., fig. 3.)

Obs.—The portion of a *Dionide* we now figure is, in many points, a very peculiar one. There are in all twenty-two segments preserved, apparently all coalesced, and without any sign of free terminations to the pleuræ. If this appearance is not deceptive, we are here dealing with a much elongated pygidium, and not a combination of coalesced tail-segments with free thoracic rings, in which case the specimen is quite distinct from either of the preceding forms. It appears to be nearest to our *D. Lapworthi*, but if only a pygidium, is much longer than that portion of the latter, and also less in width. The pleural grooves and ornamentation are, however, similar. If this represents a combined thorax and pygidium, in which the free ends of the former have become obliterated, there would then, allowing the six most anterior somites to the thorax, be sixteen in the pygidium, a similar number to that possessed by *D. Lapworthi*, so far as we are able to count them in the somewhat damaged specimen of the latter species. In the elongated form there is a certain resemblance to *D. atra*, Salter,[1] but the relative sizes of the axes, as compared with the pleuræ, differ. It is possible this may be only a condition of our *D. Lapworthi*, but for the present we prefer to keep them separate.

Loc. and Horizon.—Whitehouse Bay, near Girvan, as before. (Gray Collection.)

Dionide (?) *sp. ind.* (*c.*)

(Pl. XX., fig. 4.)

Obs.—This peculiar little tail we refer to *Dionide* with doubt. It consists, as preserved, of six segments and a long terminal appendage to the axis, reaching to the posterior margin. The divisions of the side-lobes are six or eight, and each bears

[1] Mem. Geol. Survey, iii. t. 11^a, f. 9 and 9^a.

an oblique pleural groove, without ornamentation. It has an oblong, or almost square form.

Loc. and Horizon.—Whitehouse Bay, near Girvan, in a thin flaggy shale of Lower Silurian age. (Gray Collection.)

Dionide, *sp. ind.* (*d.*), immature form.

(Pl. XX., fig. 5.)

Spec. char.—Body small, oval. Head-shield semicircular; posterior margin curved, not truncate; glabella indistinctly preserved, reaching almost to the front margin of the shield; lateral portions of shield finely punctate, but without diagonal ridges; shield produced backwards at the angles into genal spines, which reach as far behind as the commencement of the pygidium. Thorax of four segments; axis narrow in proportion to the width of the pleuræ, nodular as usual; pleuræ distinctly divided by the groove, and with faint traces of ornamentation on the fore part of each. Pygidium semicircular, consisting of nine thoracic and eight pleural coalesced segments, coinciding more or less in character with those of the thorax.

Obs.—M. Barrande has shown that *Dionide*, amongst other genera, underwent a metamorphosis. He gives a figure of the young condition of *D. formosa*,[1] with four free thoracic somites and eight or nine coalesced pygidium segments, possessing in every respect a very close resemblance to the little fossil now under description. The latter, however, appears to be proportionately longer in all its parts, and the cephalic spines extend backwards only to the pygidium, although it is a question if they have not been shortened by fracture, instead of being extended beyond the body as in the former case. It is impossible, in the absence of intermediate examples, to indicate in what relation this little *Dionide* stands to any of the foregoing described forms. The four-segmented thorax shows it

[1] Syst. Sil. Bohême, i., Suppl., t. 1, f. 18 *a* and *b*.

to be an immature specimen, and we must in consequence withhold an opinion on its identity for the present.

Loc. and Horizon.—Whitehouse Bay, in a dark flaggy shale of Lower Silurian age. (Gray Collection.)

It will perhaps be better to at once refer to some further remains of Trilobites, which appear to be referable to *Dionide*, rather than to describe these as merely indicated species. This is the more necessary on account of the difference which has been shown to exist by M. Barrande between the young and mature conditions of the type-species, *D. formosa.*

In fig. 2, Pl. XX., is represented a small pygidium having the many-segmented axis of *Dionide*, and with the divided and bent-down terminal pleuræ of that genus; the ornamentation is not preserved. It is possible this may be the tail only of the foregoing species, under a somewhat different aspect of pressure, but as preserved, it is in proportion much broader than that of *D. Lapworthi*, much less in length from before backwards (if wholly preserved), and apparently with a narrower axis. M. Barrande, however, gives two forms of tail to *Dionide formosa*, one[1] with the longer axis from before backwards, the other with the distance between the lateral margins representing the longer axis.[2] Fig. 2, Pl. XX., may be simply the latter condition of our *D. Lapworthi.* We leave its exact identification an open question for the present.

Loc.—Whitehouse Bay.

Genus Agnostus, Brongniart, 1822.

(See *Fasciculus II.* p. 200.)

Agnostus perrugatus, Barrande?

(Pl. XX., figs. 6-7.)

A. perrugatus, Barr., Syst. Sil. Bohême, i., Suppl., p. 143, t. 14, f. 14-16.

Spec. char.—Head-shield more or less trapeziform, the long base corresponding to the front margin, concentric limb en-

[1] Syst. Sil. Bohême, i., Atlas, pl. 42, f. 24. [2] *Loc. cit.*, f. 15.

larging towards the front. Glabella a little less than half the length of the entire head, and about one-third of its breadth. The axal grooves are plain and well defined, subparallel, or inclined to be slightly concave about the middle of the glabella, but at the base curving outwards, and, with the assistance of two additional grooves curving inwards, cutting off two small basal, triangular glabella-lobes. The fore part of the glabella is subdivided by two transverse, somewhat arched grooves into three unequal lobes. The frontal, or most anterior of the lobes, is rounded towards its fore part, and is the second in point of size; the median and smallest lobe corresponds in form to the bounding grooves; whilst the third and largest lobe is gradually attenuated towards the posterior margin of the glabella, by the cutting off of the small lateral triangular lobes. The cheek-margin gradually widens towards the front of the head, and is bounded by the limb; it is ornamented, both in front and on the sides, by subregular, strong, radiating, and bifurcating ridges.

Thoracic rings not preserved.

The pygidium generally resembles the head-shield in form. It is, however, a little longer, and may be said to be generally rectangular, enlarging towards the posterior margin. The axis consists of three principal lobes, defined by two transverse grooves, in conjunction with the axal furrows, which are well marked; the two anterior lobes are of about the same size, and less than the last lobe, which is rounded on its posterior margin; (the two anterior lobes are subdivided by a vertical or longitudinal prominent tubercle, approximating to the anterior margin of the tail.) Tail-margin enlarging towards the rear, and ornamented in a similar manner to the cheek-margin of the head-shield; (limb smooth, enlarging posteriorly, and terminating at the angles in short spines).

Obs.—A lengthened search through the literature of the genus *Agnostus* has not brought under our notice a more fitting resting-place for the present remains than Barrande's *A. perrugatus*. At any rate, our form is so close to this, that

we should not be warranted in establishing for it a new name, with the limited material now before us. The characters in our description which are inserted in brackets, show those points not observed with certainty in the Girvan specimens, but which are given by M. Barrande as distinctive of his species. As regards the limb surrounding the cheek- and tail-margins, we believe this to be simply hid by irremovable matrix in our specimens; and as to the tubercle on the axis of the pygidium, it is a question if the remains of this are not actually present. On the whole, therefore, we regard our determination as open to little doubt, the only valid departure we can point out between the Bohemian and Scotch examples being the somewhat coarser radiating ridges of the cheek- and tail- margins in the latter. M. Barrande has already shown the relation of *A. perrugatus* to *A. exsculptus*, Angelin,[1] and *A. Moorei*, Salter.[2]

Agnostus princeps, Salter,[3] has light radiations on the margin, but nothing to be compared with the present species; and in addition, the divisions of the glabella and tail are different from those of the latter. *A. Americanus*, Billings,[4] possesses irregular, radiating, rugose striæ on its fringes; but here, again, the subdivisions of the glabella and tail-axis are dissimilar to those of our species. In the following Trilobites the fringes are highly reticulate or punctate, but not in the least marked with radiating ridges—viz., *Agnostus aculeatus*, Angelin;[5] *A. punctuosus*, Angelin;[6] and *A. nodosus*, Belt.[7]

In the absence of the limb-spines, and the doubtful presence of the axis-tubercle, we regard fig. 7, Pl. XX., as the pygidium, rather than glabella, similar to fig. 6, on account of its greater relative length, and absence of any basal lobes like those of the latter illustration.

[1] Pal. Suecica, 1854, p. 7, t. 6, f. 8.
[2] Quart. Jour. Geol. Soc., xxii. p. 486, figs. *a* and *b*.
[3] M. G. S. Dec., xi. t. 1, f. 1-5.
[4] Pal. Foss. Canada, p. 396, f. 372, *a* and *b*.
[5] *Loc. cit.*, p. 8, t. 6, f. 12. [6] Ibid., p. 8, t. 6, f. 11.
[7] Geol. Mag., iv. p. 295, t. 12, f. 3, *a* and *b*.

Loc. and Horizon.—Shore at Whitehouse, near Girvan, in a dark-grey to blue, hard, hackly-fractured, calcareous shale, of Lower Silurian age. (Gray Collection.)

In Bohemia *A. perrugatus* is found in the schists of Band D 1, the equivalent of our Lower Llandeilo, or Arenig rocks.

Sub-class CIRRIPEDIA.

Order THORACICA (*Continued*).

(See *Fasciculus II.* p. 213.)

Genus TURRILEPAS, H. Woodward.

(See *Fasciculus II.* p. 213.)

Obs.—Additional evidence of the occurrence of this genus in the Girvan rocks has been obtained since the publication of our last Fasciculus, which renders it necessary that we should return to the study of it.

The arrangement of the plates in *Turrilepas* has been studied and explained by M. Barrande and Dr H. Woodward. Through their researches we learn that the plates are disposed in numerous regular and parallel vertical series round an imaginary axis, with the acute or pointed end of the various plates directed to a greater or less degree towards the summit or aperture of the organism, in such a manner that their longer axes are, to all intents and purposes, parallel with the longer axis of the body. The number of these rows is variable, but they are so disposed that in contiguous series the plates are alternate in position, and partially cover one another laterally. In addition to this, the plates of each series are strongly imbricate from below upwards, and resemble one another in form.

Each series appears to be composed of plates differing in outline from those bordering it; at any rate this holds good so far as the structure of *Turrilepas* is at present known. Dr Woodward has shown that in *T. Wrightii* there are certainly four series, of different forms to one another—an elongated,

kite-shaped series on each side of the organism, with two central rows of more expanded, inequilateral, and dissimilar plates.[1] Similarly, M. Barrande remarks that the longer (or more kite-shaped plates) form the series near the borders of the organism, whilst the shorter (or broader) plates are arranged near the middle of the test.

Opinions appear to differ somewhat as to the analogy of the parts in *Turrilepas*, although both Woodward and Barrande agree in considering the whole organism as allied to *Loricula*. The former[2] clearly believes the at present known remains of *Turrilepas* to represent the peduncle of *Loricula*, as defined and understood by Dr Darwin; on the other hand, M. Barrande considers it to follow from this, if we adopt Dr Woodward's views, that we are not yet acquainted with the opercular valves forming the capitulum of *Turrilepas*, but that the plates at present known to form the body of *T. Wrightii* represent simply the peduncle. It must, however, be borne in mind that M. Barrande has pointed out the existence of another form of valve, termed by him the "cancellated plate" (*valve fénestrée*), and of which the precise position and use in the economy of *Turrilepas* are not at present understood. It will be in the remembrance of our readers that we have shown the existence of a similar plate both in the Silurian rocks of Girvan and the Pentland Hills, associated with the other remains of this genus.

Speaking broadly, there is a rough kind of bilateral symmetry in the manner in which the pointed, or "kite-shaped," plates are arranged on the opposite sides of *Turrilepas*. This is seen in the largest and best preserved of Barrande's specimens,[3] as well as in Woodward's figure;[4] and both agree, also, in the position of these plates, with their longer axes almost parallel with that of the body. A better illustration of this bilateral symmetry, if it may be so called, is seen in one of Mrs Gray's examples from Girvan. Unfortunately, as in the case of many other specimens exhibiting important details, the one now in question

[1] Quart. Jour. Geol. Soc., xxi. p. 488, t. 14, f. 1 *h*, 1 *l*.
[2] Ibid., 488.
[3] *Loc. cit.*, t. 20, f. 1.
[4] *Op. cit.*, t. 14, f.

is only a fragment. Still there are visible two rows, or series, of broadly V-shaped scales in the central line, having on each side a series of the elongated, or kite-shaped plates, but with this difference, that the latter instead of being parallel with the longer axis of the specimen, are placed more or less at right angles to it, with a slight curve upwards. Three other specimens, a good deal compressed, but all more or less entire, show this in a less marked degree, but still sufficiently to attract attention when compared with *T. Wrightii.*

Again, the more perfect specimens figured by M. Barrande exhibit a strange angularity, or crestiform appearance along the middle line of the individual, which, though now partially crushed, must have had some relation to the original form of the animal. Curiously enough, there is in one of the most perfect specimens from Girvan a similar well-marked ridge.

Although the remains collected by Mrs Gray differ a little in the size of the plates amongst themselves, we are unable to look upon them as other than those of a single species, most undoubtedly distinct from *T. Wrightii*, de Kon., sp., and equally so from our *T. Scotica*, but allied to one of Barrande's forms, although, so far as we can make out, dissimilar to this last in many points. We propose to describe this under the name of *T. Peachii.*

Turrilepas Peachii, Eth. and Nich. (*sp. nov.*)

(Pl. XX., figs. 8-10.)

Spec. char.—Body elongated, of the usual form met with in the genus, having on one side at least a central longitudinal keel or carinal ridge, on each side of which the larger kite-shaped plates are bilaterally arranged, more or less at right angles to it in the lower part of the organism, but becoming, *apparently*, more and more parallel with it towards the apex of the body. Component plates or scales of two orders (so far as preserved), the large, elongated, curved, kite-shaped plates, and

the broad, short, more or less arched plates, with a senicated lower margin. The former occupy the sides of the body, and are at right angles to the longer axis as before described, with a strong narrow median keel, and ornamented with broad, flat, and somewhat distant, imbricating lamellæ, which pass over the keel, and become crowded together, and deflected rapidly towards the apex of the plates on the most convex margins of the latter; the apex of these plates is simply bluntly-pointed. The arched plates are not distinctly visible, but their ornamentation is similar to the kite-shaped ones.

Obs.—We much regret that the fragmentary state of our specimens does not permit us to give more particulars of this interesting form. No comparison with the Dudley species is required, as they are at once seen to be distinct. The kite-shaped plates of *T. Peachii* appear to be less curved than those of *T. Scotica*, nobis, and we have not been able to detect any trace of the finely-drawn-out needle-shaped superior extremity of the plates of that species. Again, the ornamentation is quite different in both forms. In *T. Scotica* the concentric ridges are exceedingly fine, numerous, and close set; on the other hand, those of the present species, as above described, are coarse and strong, wide apart, and with the imbricating character well displayed.

From *T.* (*Plumulites*) *Bohemicus*, Barr.,[1] which our species resembles in size, the latter may be distinguished by the much stronger and narrower longitudinal ridge of the larger plates, and the nature of the imbricating laminæ. It approaches nearest, apparently, to *T. regius*, Barr.,[2] but the form and ornamentation will again act as distinguishing marks.

We have much pleasure in naming this in honour of our friend Mr B. N. Peach, of the Geological Survey of Scotland.

Loc. and Horizon.—Whitehouse Bay, in a similar bed to the species above described. (Gray Collection.)

[1] Syst. Sil. Boh., i., Suppl. Atlas, t. 20, f. 1 *a* and *b*. [2] Ibid., t. 20, f. 6 and 7.

Class Annelida.

The class Annelida appears to be represented in the Girvan area to a very limited extent. Only one genus of Tubicola has hitherto been recognised, and we are not in a position to increase the number. Tracks of Worms or Annelid markings —so called—have been found in one or two localities, and will be treated of in succeeding pages.

Genus Serpulites, Macleay, 1839.

Serpulites, Macleay, Murchison's Sil. Syst., 1839, p. 700.
„ „ Annals Nat. Hist., 1840, iv. p. 387.
„ M'Coy, Brit. Pal. Foss., Fasc. I. 1851, p. 132.
„ Etheridge, jun., Geol. Mag., 1880, dec. 2, vol. vii. p. 304.

Obs.—The structure of this genus has been amply treated of by its author, Professor M'Coy, Mr Salter, and others, and recently more fully by one of the present writers, to whose remarks we would beg to refer those interested.

Serpulites longissimus, Murchison?
(Pl. XX., fig. 12, 13.)

S. longissimus, Murchison, Sil. Syst., 1839, p. 608, t. 5, f. 1.
„ „ M'Coy, Brit. Pal. Foss., Fasc. I. 1851, p. 132.
„ „ Salter, in Murchison's Siluria, 1867, 4th ed., t. 16, f. 1.

Spec. char.—Tube subcompressed, tapering, thin, glossy; thickened margins rod-like, narrow, but well marked; surface here and there wrinkled longitudinally, and crossed by obtuse undulations, somewhat more than their own distance apart, now and then losing their obtuse character, and becoming fine and sharp.

Obs.—We are by no means satisfied that the three specimens before us belong to Murchison's species. Professor M'Coy remarks of the latter, "tapering at the rate of only two lines in five inches." Now, our first specimen, measuring three inches in length, has a continuous breadth of five lines, almost that of the

figured example of *S. longissimus*, and may perhaps be fairly assumed to be that species. Both the other examples taper rapidly, one especially so. The latter, slightly curved, is four inches one line long, with a breadth of four lines at the wider end, and one line at the pointed extremity. The other specimen is three inches in length, likewise curved to some extent, and tapering in nearly the same ratio to that just described, the measurements in this case being five lines at the broadest end, and two at the smallest. Whether *S. longissimus*, Murchison, tapers to so fine an extremity, we are unable to say; certainly we have not met with an example of it, and so far as we are aware, no description yet published appears to comprehend the whole organism. The regular and rapid attenuation of the tube in the second instance above described, very closely resembles that of *Serpulites dispar*, Salter,[1] but this is described as possessing only a width of two lines in its widest part. For the proper determination of these worm-tubes, two things are necessary—a knowledge of the entire organism, and the requisite allowance in giving measurements to be made for compression.

Loc. and Horizon.—Drummuck Burn, in a fine-grained dark mudstone; Penwhapple Glen, in a similar matrix. (Gray Collection.)

THE SO-CALLED WORM-TRACKS OF THE GIRVAN DISTRICT.

We have now to consider a most problematical series of so-called organic remains, by some writers supposed to be the trails of Errant Annelides, or castings of their burrows; by others the tracks of Mollusca; and by some the markings made by Crustacea; while there are not wanting those who have advanced the view that they represent the actual bodies of the worms, now replaced by mud. Lastly, the vegetable origin of some of these enigmatical markings has been advocated from time to time.

[1] M'Coy's Brit. Pal. Foss., p. 132.

Those which will be specially referred to in this portion of our Monograph are known under the names of *Nereites*, *Myrianites*, *Nemertites*, and *Crossopodia;* and in referring to them, we shall freely avail ourselves of some remarks on the subject made by one of us in a recent publication,[1] in addition to other observations mutually made since the former was written.

1. Nereites (*Macleay*, 1839).—The markings or impressions known under this name are described as of considerable length, consisting of a central axis of nearly equal width throughout, with, on each side, a series of thick, short, lobe-like projections, called feet, and each surmounted by a small marking compared to the segmental foot-tubercles of the Annelida.[2] Two conditions of this form have been described from British Silurian Rocks—*Nereites Cambrensis*, Murchison, and *N. Sedgwickii*, Murchison. The red micaceous flagstones of Penwhapple Glen have yielded a specimen (Pl. XXIII., fig. 1), faintly preserved, which may perhaps be referable to the former. It is, at the best, very indistinct, but appears to be composed of a median linear axis, with lateral protuberances, separated by interspaces, both the former and latter being rather irregular in their outline, although the protuberances show a tendency to the rounded form. In addition to *Nereites Sedgwickii*, this faint impression equally resembles a supposed plant, the *Phyllocorda sinuosa*, Ludwig,[3] and another problematical fossil, *Nereograpsus Jacksoni*, Emmons,[4] which will be referred to hereafter

Loc. and Horizon.—Penwhapple Glen, in red micaceous flagstone. (Gray Collection.)

2. Myrianites (*Macleay*, 1839).—The usual definition applied to the markings known under this name is, that the body is curved in long transverse folds or irregular undulations, longer and more slender than in *Nereites*, with indistinct

[1] Manual of Palæontology, 2d edit., 1879, pp. 320-326.
[2] Sil. System, 1839, p. 700; M'Coy, Brit. Pal. Foss., p. 128.
[3] *See* Schimper, Handb. der Pal., 1879, ii. Bd. 1 lief., p. 50.
[4] American Geol., 1855, i. pt. 2, t. 2, f. 2.

"feet," furnished with short "cirri,"[1] or, more properly, "foot-tubercles." In ordinary specimens, all that is seen is the surface of the matrix, marked by winding and tortuous linear impressions or markings, of extremely small comparative width, and easily recognisable from it by their darker colour and slightly different texture. These meandering markings wind over the surface of the stone in indefinite undulations; in one so-called species, *M. tenuis*, M'Coy, often appearing to cross one another—although, in the typical "species," their arrangement is a much more regular one. Prof. M'Coy, in his description of the former, says, "I have only in one part seen traces of the cirri;" but so far as our own observation has gone, we have not observed a trace of any such structure, although a large number of examples have been examined. We have from the Girvan area three kinds of markings or impressions which may perhaps be referred to *Myrianites*. The first of these (Pl. XXIV., fig. 1) consists of a thin raised ridge, or depressed line forming narrow, more or less parallel, concentric loops, spreading over a considerable surface, each loop expanding somewhat towards its lateral extremities. These markings differ from the typical *M. Macleayi*, Murchison, in the expansion of the termination of the loops, the absence of a truly coiled or concentric condition of their arrangement, and the occasional intersection of the markings by one another in their course. The second form resembles the first, in so far that the terminations of the loops (Pl. XXIII., fig. 2) are enlarged; but they differ in their greater regularity, there being a tendency to a much more complete concentric arrangement; while the tracks do not cross one another so far as observed. The third description of marking which would fall under the name *Myrianites* consists of meandering, convoluted, or interlacing little raised runs of great length, at times tremulous in their course, at others firm, enclosing either elongated, but irregular or rounded and oval spaces (Pl. XXIV., fig. 2). This last condition appears to be, without doubt, the *M. tenuis*, M'Coy.

[1] Sil. System, p. 700; M'Coy, Brit. Pal. Foss., p. 129.

Myrianites Macleayi, Murchison,[1] is composed of a series of elongated narrow subparallel coils graduating towards a central point; and according to the figure in the "Silurian System," the body gives off a number of close, short, straight processes, the so-called "cirri." Such a form, with the latter in position, we have not seen from Girvan; but eliminating these cirri from consideration for the moment, tracks in the form of long curved transverse loops, as in our second case, just cited, are common enough, assuming to some extent the more or less circular form seen in Murchison's figure. These may be a condition of *M. Macleayi*, or they may be only referable to the next form about to be noticed.

The persistence of these markings referred to *Myrianites* is remarkable, Dr E. Emmons having described similar ones under the name of *M. Murchisoni* and *M. Sillimani*,[2] from his Taconic System of the United States of North America, and in this respect we see a repetition of the facts pointed out by us previously in the case of *Nereites*. *M. Sillimani* and *M. Murchisoni* are composed of a series of regular, narrow, graduating, concentric loops, exactly as in the typical British species.

3. Crossopodia (*M'Coy*, 1851 = *Crossochorda* (pars), Schimper, 1879).—Another of these so-called genera, *Crossopodia*, M'Coy, was established[3] to include supposed worms with a long slender body, composed of short, numerous, wide segments, and clothed with "very long, delicate, crowded cirri, forming a broad dense fringe on each side."

The presence of this form at Girvan depends, so far as we have seen, upon a single doubtful specimen (Pl. XXIV., fig. 3), which has the arrangement of the loops as in *Crossopodia*, but with the intimate structure somewhat different. The surface of the track is a little raised above that of the slab, and flattened, but without any appearance of the arched form of *Crossopodia*, the central ridge, or the transverse markings. Where the sur-

[1] Sil. System, t. 27, f. 3.
[2] Agric. of New York, 1846, i. p. 69, t. 16, f. 1 and 5.
[3] Annal. Nat. Hist., 1851, vii. p. 395; Brit. Pal. Foss., p. 130.

face has been accidentally removed, the particles in the interior of these loops appear to have undergone rearrangement, and instead of either coinciding with the matrix, or having merely a confused appearance, are seen to be in curved lines across the abraded tracks, resembling, as it were, a series of small cups or shallow cones. In other portions of the track, however, where the surface has been likewise removed, this rearrangement of particles is wanting; and from the confused state of the latter, the track has every appearance of having been hollow. Now this track is to a certain extent identical with the second form described under *Myrianites*, but in the present case the loops are continuously drawn out, and lack the concentric condition of the latter. It is to all intents and purposes a *Crossopodia*, with the body preserved, and the lateral striated portions removed. Both these conditions are particularly well shown in the figure of *C. Scotica*[1] given by Professor M'Coy, which will serve to illustrate our meaning. It is possible that another fragment with lateral striations, and of which we give a figure, (Pl. XXIII., fig. 3), may also be a *Crossopodia*. The geological range, like the geographical distribution of *Crossopodia*, is extensive. It is met with in the Silurian rocks of the United States, and has been described under the name of *C. Loomisii*, Emmons, sp.,[2] whilst two conditions have been noticed from the Carboniferous beds of Northumberland—*C. Embletoni*, G. Tate,[3] and *C. media*, G. Tate.[4] Another slightly different form has been found in the coal-measures of Queen's County by the Rev. Professor Haughton, and figured by him.[5]

4. Eione (*G. Tate*, 1859).—In this "genus" the body is composed of a series of bead-shaped rings, separated from one another by deep sulcations, resembling in many respects a deeply-cleft *Orthoceratite*, or like the separated siphuncle of the genus *Actinoceras*.

[1] Brit. Pal. Foss., t. 1, D. f. 15. [2] Agric. of New York, 1846, i. p. 69, t. 15, f. 3.
[3] Trans. Berwickshire Nat. Field Club, 1863, iv.
[4] Ibid. (See also Trans. Tyneside Nat. Field Club, iv. p. 22 *et seq.*, Pls. 5-8, in a paper by the late Mr Albany Hancock.)
[5] Jour. Geol. Soc. Dublin, 1858, viii. pt. 1, p. 87, Pls. 8-11.

The same beds at Penwhapple Glen yielding the markings previously noticed have furnished several runs composed of a series of rounded depressions following one another in close order, and so forming a continuous, more or less moniliform chain (Pl. XXIV., fig. 4). It is possible that the more perfect state of these would resemble Mr Tate's *Eione moniliforme*[1] of the Carboniferous series.

5. Two other kinds of tracks remain to be briefly noticed. The first of these (Pl. XXIII., fig. 4) is formed by a series of small but broad, rather flattened, closely bent convolutions, following rapidly on one another. They are margined on one side by a depression following the convolutions, and corresponding in width to that of the latter. The second to be referred to (Pl. XXIII., fig. 5) is a simple meandering trail, crossing and recrossing itself at intervals, at times represented by a ridge, at others by a groove. The ridge appears to be bordered on one side or the other, and at times on both, by a groove. Similar tracks to this have been referred, both in Silurian and Carboniferous rocks, to *Nemertites*, Macleay. From the former they have been described by Professor Hall,[2] and from the Carboniferous by Mr G. Tate, as *N. undulata*.[3]

Considerations as to the Identity and Character of these Trails and Markings.—It may not be out of place to recapitulate the fact that the tracks known under the names of *Myrianites*, Macleay, *Nereites*, Macleay, *Nemertites*, Macleay (= *Nereograpsus*, Geinitz), *Crossopodia*, M'Coy, and *Eione*, G. Tate, have, one or all, been considered to be—

a. The trails of soft-bodied Annelids (Emmons, Hall, and others).
b. Structures representing the actual body of the worm itself (Murchison, M'Coy, &c.)
c. The tracks of Gasteropoda (Hall, &c.)
d. The tracks of Crustacea (Albany Hancock, Hall, and others).
e. Structures representing the remains of marine plants (Professor Schimper and others).

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[1] Geologist, 1859, ii. p. 68, t. 2, f. 6; Trans. Berwickshire Nat. Field Club, 1863, iv.
[2] Pal. New York, ii. p. 32. [3] *Loc. cit.*

It is of course almost superfluous to observe that in these tracks and trails we have no trace of the remains of organic matter, in the true sense of the word. They are supposed to have been formed by the animal, if a worm, or mollusc, dragging its body over the surface of wet sand or mud, between tide-marks, or in shallow water; and from such a point of view the presence of actual organic matter cannot be expected. As regards any which may be of vegetable origin, the organic matter has been entirely removed,—a phenomenon by no means confined to the Silurian rocks, as the same is frequently found to be the case with those remains in strata of the Carboniferous period, about the vegetable origin of which there is no doubt.

Now, looking at the markings known as *Nereites*, *Myrianites*, and *Crossopodia*, in the first place, it is difficult to conceive, as suggested by Professor Schimper, how a soft-bodied animal like an Annelide could, in passing over mud, or any other more or less yielding deposit, avoid defacing, to a great extent at least, by the hinder part of its body, the first-formed portion of its track. It would hardly be possible for the resultant impression to have that clear, sharp, and well-defined appearance so frequently exhibited by these tracks. As another argument against an Annelidous affinity, Schimper points out the extreme length to which these markings sometimes extend: the longest known living member of the class he states to be the *Lumbriconereis gigantea*, Quatref., which does not exceed a length of sixty centimetres. Another point which appears to be equally against the usually accepted affinity is the fact that these tracks or trails frequently take a sudden bend in a contrary direction to their former course, without disturbing in the least the regularity and bilateral symmetry of the so-called "feet" and other parts.

Schimper, in abandoning the Annelidan affinities of *Nereites* and other similar forms, has placed them amongst the Algæ, proposing for their reception the group *Chordophyceæ* (lace- or ribbon-algæ).[1] Two of the chief reasons for this change are

[1] Handb. der Pal., ii. Bd. 1 lief., p. 48.

the dichotomisation, which he says is sometimes visible, and the occasional presence of a broad thallus-like root of attachment. The latter is seen in the figure of *Phyllochorda sinuosa*, Ludwig, sp., from the Devonian rocks of Thuringia, and in a great measure induces us to believe that the typical *Nereites*, at least, are in all probability the remains of a plant with the whole of the organic matter removed.

Another point in favour of Schimper's reference of these remains to the Plantæ lies in the fact that the lower end frequently presents the central axis devoid of the lateral prolongations, resembling as it were the basal bare portion of the midrib in a *Laminaria*. This is exhibited in a form described by Emmons, *N. Jacksoni*,[1] which, if congeneric with Murchison's typical species, seems to us to be simply an impossibility as the work of an Annelide, to say the least of it.

With regard to *Myrianites*, we may first consider the smaller form of markings to which the name of *M. tenuis*, M'Coy, has been given; and we cannot do better than quote here some remarks recently made on this subject by one of us,[2] which to a very great extent have tended to settle the nature of the markings.

In ordinary markings of *M. tenuis* "all that is seen is that the surfaces of the strata are marked by winding and tortuous linear impressions, of extremely small comparative width, and easily recognisable from the matrix by their darker colour and slightly different texture. These meandering markings wind over the surface of the stone in indefinite undulations, often appearing to cross one another; and no one, looking at such a specimen, would be inclined to doubt that he had to deal with the trails left upon the mud of the sea-shore by some soft-bodied marine animals, though he might question if these could be Annelides. Other specimens, however, of the same fossil, which have been carefully examined by the author, prove conclusively that, in spite of appearances, *Myrianites* is

[1] Agric. New York, i. p. 69, t. 15, f. 1.
[2] Man. of Pal., 2d ed., pp. 321-323.

not only not Annelidan in its nature, but that it cannot possibly be the *track* of any animal whatever. It can be shown, in fact, that the narrow serpentine markings upon the surface of the stone, which are universally understood under the name Myrianites, are really *the cut edges of thin vertical laminar expansions, sinuously folded, and seen in horizontal section.* In fig. 10, a portion of one of the specimens referred to is figured, from which it will be seen that the fossil *cuts directly across the laminæ of deposition*, its actual surface (where exposed by ex-

Fig. 10.—Fragment of a slab, showing *Myrianites tenuis*, from the Silurian slates of Thornilee, Peeblesshire, of the natural size. The slab has split at different levels in different parts, and the fossil is seen to cut vertically across the laminæ of deposition, the surfaces thus formed being concentrically striated.

foliation of a part of the slab) being marked with concentric striæ. It is therefore quite clear that Myrianites was really a thin, erect, folded, leaf-like expansion, of some kind or another, and that what palæontologists have described under this name is only the horizontally cut edge of this expansion as seen on the surface of the stratum. What *Myrianites* really is, is quite an open question. It is, perhaps, a peculiar form of Fucoid. That it is not Annelidan seems perfectly certain." On further

and careful consideration, we do not see how, if *M. tenuis* is to be regarded in the light of the remains of an organism, it can be looked upon as other than those of an erect sea-weed of large proportions; but we think it doubtful if it can lay claim to be considered as of organic origin at all.

It will be more convenient to consider next, in conjunction with the preceding, the subparallel transverse loops we have provisionally referred to *Myrianites*, and those meandering or tortuous windings noticed in our fifth paragraph. That these are the trails of some Invertebrate animals, we have not the slightest reason to doubt. One of the chief points of interest in connection with them is their very wide distribution, occurring as they do in the Silurian rocks of both the Old and the New World, and extending as high as the Carboniferous series.

Professor James Hall remarks[1] of them, "Tracks of various animals, some of which, as they passed over or just beneath the surface of the sand, have left a certain furrow or trail. . . . From the character of the surface of the arenaceous beds in which they occur, I am inclined to the belief that many of them were made while the bed was exposed above the water, and most of the others in very shallow water."

Hall states that the general character of these trails is "that of a meandering furrow, more deeply depressed at the two sides, elevated at the centre, and margined by a slightly elevated ridge of sand, which appears to have been pushed outward in the progress of the animal. Others of them are a simple furrow, with the deepest depression in the centre. . . . In their general character some of them are not unlike the trails made by *Natica* or *Littorina*, and others are more like the meandering trails of *Idotea*. In many the great length of the meandering line, which crosses and recrosses itself many times, seems to indicate that the animal moved rapidly over the surface. In others the trails are larger, and

[1] Pal. New York, ii. p. 26.

the animal probably moved much more slowly, the length being often limited to a few inches.'[1]

As the recrossed tracks are supposed to indicate rapidity of movement, Hall considers that they can hardly be those of Gasteropoda, for the members of this class as a rule move slowly, but *Idotea* moves with considerable rapidity. In illustration of these views he further adds,—"The trails of *Melania*, made on sandy and muddy bottoms beneath shallow water, are more similar in their meandering direction and recrossings" (*i.e.*, to the markings in question) "than the trails of *Natica*, which are usually of no great extent. The *Melania*, on the contrary, often leaves a trail of several feet long, winding about in this manner; but the trail in this case is a simple depression, margined by a slight ridge, produced by the animal pushing away the material from before it, and piling it up on each side. The tracks of *Littorina* on a sandy beach resemble these in some degree; but they are usually more direct, and show fewer recrossings in the same space."[2]

Similar wandering tracks which occur in the Carboniferous rocks of the north of England have been referred to the Mollusca by Mr E. W. Binney. He has compared them to those of *Littorina littoralis* and a bivalve.[3]

The remarks of Professor Hall, and of other observers who have made both these tracks and trails, and those of living Mollusca, their study to a very great extent, appear to be so conclusive, that we feel ourselves obliged to accept them as an explanation of those markings represented by our figures (Pl. XXIII., figs. 4 and 5; Pl. XXIV., figs. 1 and 4). It has been objected by one of us,[4] in reviewing this subject, that it is almost inconceivable that traces of the animals should not have been found in company with the tracks and trails originated by them. It is a curious fact, that in the finely levigated

[1] Proc. American Assoc. Adv. of Science, Cambridge, 1849, p. 256; Pal. N. York, ii. p. 26.

[2] Pal. N. York, ii. p. 28.

[3] Trans. Lit. Phil. Soc. Manchester, x. p. 189, t. 1, f. 1, t. 2, f. 1.

[4] Nicholson, Palæontology, 2d ed., p. 325.

deposits in which they are found there should be, as a rule, such an entire absence of the remains of veritable organisms which might have given rise to them. The objection, however, is only one of secondary importance when compared with the undoubtedly important facts which have been adduced by various writers to account for the origin of such phenomena.

We have to deal, finally, with the tracks known as *Crossopodia*, M'Coy, which were regarded by the author of the "genus" as the remains of veritable bodies of marine worms. Similar trails have on several occasions been noticed from the Carboniferous rocks [1] of this country, and described as *Crossopodia Embletoni* by Mr G. Tate.[2] It is also probable that the genus *Cymaderma*, of Professor J. Duns, D.D.,[3] is here referable.

By far the most important contribution which has hitherto appeared attempting to explain the nature of trails similar to *Crossopodia*, is that by the late Mr Albany Hancock.[4] He showed in the most successful manner that similar trails were produced now on the sandy beaches of our own coasts by small Amphipod Crustaceans—*Sulcator arenarius*, Spence Bate, and *Kröyera arenaria*, S. B. Both these animals burrow a little below the surface of the sand, and produce slightly different runs. That of the first species, with which we are mostly concerned, is a slightly raised track, to a certain extent ribbon-like in shape, with a median groove, transversely ridged or striated, of considerable length, and often intricate and convoluted. The sand is pushed upwards by the Crustacean, and the trail thus formed partially subsides as the creature passes on, whilst by its breaking along the centre, the median groove is formed. At intervals, the Amphipod, by thrusting itself through the sand, leaves an oval swelling; and so, by repetition, a series of roughly formed nodules is produced.

[1] "An Account of a large Fossil Marine Worm," &c., &c., by E. Wood—The Naturalist, 1851, No. 1, p. 14; No. 2, p. 41.

[2] Geologist, 1859, ii. p. 66, t. 2, f. 1 and 2; Trans. Berwickshire Nat. Field Club, 1863, iv.

[3] Proc. R. Soc. Edin., ix. p. 352.

[4] Trans. Tyneside Nat. Field Club, iv. p. 17.

In further illustration of the subject, Mr Hancock figured[1] a large *Crossopodia* from the Carboniferous rocks of Northumberland, as much as six feet in length, and in all probability identical with *C. Embletoni*, Tate. Now, in addition to the very close resemblance borne by the exterior of the underground passages of *Sulcator arenarius* to *Crossopodia*, the resemblance is made still stronger by certain appearances presented by some American Silurian *Crossopodiæ*, as described by Professor Hall. He says that at intervals along the trail of the form in question the stone is elevated into vesicular knobs, with a small opening in the centre:[2] this appears to have a strong analogy with the apertures made in its tunnel by *Sulcator arenarius!*

Although it is not by any means our intention to infer from this resemblance the existence, during Carboniferous and Silurian times, of an animal identical with the *Sulcator*, we certainly do think that, presuming no other and better explanation to be forthcoming, it must be at least admitted that such markings as *Crossopodia* may be caused by Crustaceans of some form or other. Mr Hancock suggested they might be, so far as the Carboniferous trails are concerned, the work of Trilobites,[3] and showed that the genera existing at that period might have excavated them. This explanation will hardly hold for the similar tracks of the Girvan area; because, with one or two exceptions, all the Trilobites previously described are far too large to have excavated the runs found there. The habits of Trilobites also, it is needless to observe, have been considered by many of the best authorities to be of a different nature.

As a counterpoise to Mr Hancock's valuable suggestion, we have another to offer which may perhaps take its place in this subject. Fig. 11 is a much reduced drawing by Mr C. Berjeau, from the original sketch made by Mr Robert Gray, F.R.S.E., of the trail of our common Mollusc, *Purpura lapillus*, taken from nature, as the *Purpura* made the track on firm

[1] *Loc. cit.*, pls. 7 and 8. [2] Pal. N. York, ii. p. 31. [3] *Loc. cit.* p. 32.

sand at Ardrossan Sands, Ayrshire, April 16, 1864. This trail is to all intents and purposes one form of the Carboniferous and Silurian *Crossopodia.* In the first place, it may be taken

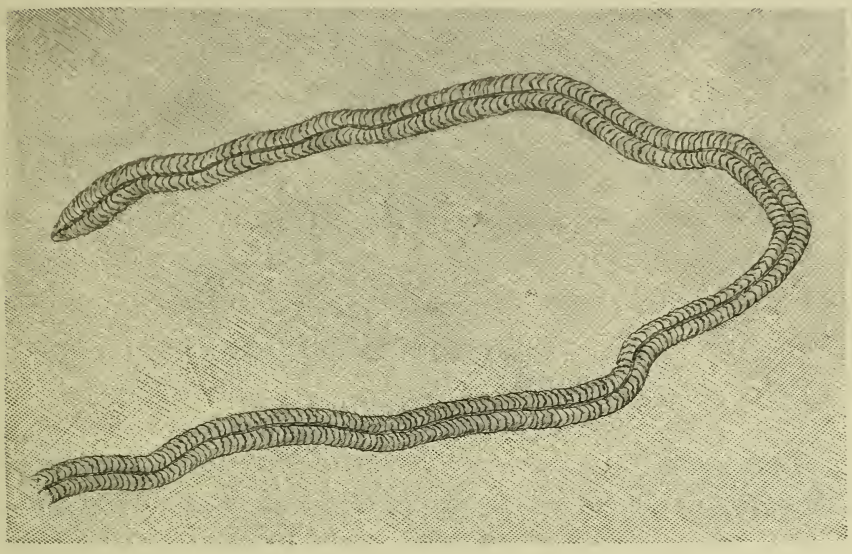

Fig. 11.—Track of *Purpura lapillus* on firm sand, Ardrossan Sands, April 16, 1864. Reduced three diameters.

to represent one of the transverse loops of that body; in the second, there is the same ribbon-like form, only a little arched, the central groove or depression representing the body of *Crossopodia*, and the transverse ridges representing the striæ.

Taking into consideration, therefore, the foregoing demonstration, coupled with the remarks by Professor James Hall, previously quoted, we think it highly probable that such tracks as *Crossopodia* are as likely to have been made by Gasteropoda as by Crustacea. Professor Schimper goes further than this, and treats *Crossopodia* from the same point of view as *Nereites;* but although inclined to support him in referring the latter to the vegetable kingdom, we cannot, at present at least, accept this resting-place for the tracks or markings now under consideration. For this form Schimper has established the sec-

tion *Diplochorda*, or doubly-ribbed Algæ, and the genus *Crossochorda* for those resembling M'Coy's *Crossopodia*.

We feel we cannot do better than conclude this interesting but difficult branch of our subject by quoting the words of our friend Professor T. Rupert Jones, F.R.S.,[1] from his interesting paper, "On Tracks, Trails, and Surface-markings," &c., as follows: "Trilobital, Bellinural, Amphipodal, and other Crustaceans, with sea-worms and Molluscs, may have made most of the trails, runs, or tracks that we have to do with in the Palæozoic rocks; and even insects may have aided in some instances, as intimated by Mr Emmons."

CLASS ECHINODERMATA.

Order ASTEROIDEA.

We possess no published information of the occurrence of this group in the Silurian rocks of Girvan. During 1879, Mrs Gray's researches have brought to light two forms of Star-fish, in the highly fossiliferous rocks of Thraive Glen, appertaining to what has usually been considered the genus *Palæaster*, Hall; but a series of observations lately made by us has convinced us that the Star-fishes usually referred to that genus in this country do not belong to it. That is to say, *Palæaster*, Salter, 1856, is not the equivalent of *Palæaster*, Hall, 1852, as now understood. To demonstrate this, and to show the affinity of the two forms from Girvan, we shall have to investigate the subject somewhat fully.

ON THE BRITISH SILURIAN STAR-FISHES REFERRED TO *PALÆASTER*, HALL.

The genus *Palæaster* was originally proposed by Prof. James Hall in 1852 [2] for an American Silurian Star-fish with five rays, these latter being composed of five or more series of plates.

[1] Geologist, 1862, v. p. 139.

[2] Pal. N. York, ii. p. 247.

Hall, in his specific description of *P. Niagarensis*, says the lower sides of the arms have "two ranges of plates on each side of the avenue, the outer range composed of strong hexagonal plates, with an inner range of smaller ones alternating," &c. There is also a large pentagonal plate inserted in each of the five angles, at the base of the arms. In 1867, Prof. Hall redescribed [1] *Palæaster*, consequent on the original specimens not showing the whole structure of these interesting fossils. *Palæaster*, according to the later definition, has two ranges of plates on each side of the ambulacral groove, in addition to the ambulacral plates, which occupy the groove itself. In other words, the under surface of each arm, as now understood, consists of six rows of plates—thus: The two alternating series of ambulacral ossicles abutting against one another in the centre, and placed in the ambulacral groove; a row on each side of these, the adambulacral, which are rather square in form; and, outside these, a row of large marginal plates on each side, or six series in all, three on each side.

This structure is plainly visible in the figures of two of Hall's species, *P. matutina* and *P. Shæfferi*, and is described in others. If confirmation of the accuracy of Hall's later descriptions be required, it may be found in those of other species by the late Mr F. B. Meek, who has invariably described [2] the ambulacral surfaces of the *Palæasters* of the Cincinnati group of Ohio as consisting of six series of plates.

Between the dates of the two descriptions of *Palæaster* by Prof. Hall, the late Mr J. W. Salter adopted [3] the name for certain British Silurian Star-fishes without a disc, and having deep avenues bordered by very large plates, his conception of the genus being based on Hall's first definition. Mr Salter's later descriptions are based upon the same supposition; and in this he has been followed by most British and a large number of European palæontologists.

[1] Twentieth Annual Report N. York State Cabinet, p. 282.

[2] Ohio Geol. Report, 1873, i. pt. 2, pp. 58-66.

[3] Brit. Assoc. Report for 1856, pt. 2, p. 76; Annals, Nat. Hist., 1857, xx. p. 324; Mem. Geol. Survey, 1866, iii. p. 289.

It follows, therefore, that *Palæaster*, Salter, is not *Palæaster*, Hall, as now understood by American authors; and it is by their view we must be guided in this matter, otherwise endless confusion would arise in the nomenclature of these Silurian Star-fishes. The whole matter resolves itself into one question—Have, or have not, the British species six rows of plates on the ambulacral surface of the arms, or only four? If the former, they will fall within the genus *Palæaster*, Hall. On the other hand, if only four plates are there to be found, they cannot be so placed, and *Palæaster*, Salter, becomes a term of no meaning,—and the species so termed must be referred to one or other of the many genera of Palæozoic Star-fishes already proposed; or failing this, a new genus must be created for them.

The two species of Star-fish discovered by Mrs Gray at Girvan have the ambulacral surface composed of four rows of plates, without the slightest doubt, and are therefore members of the group *Palæaster*, Salter.

We have carefully examined all the British species of so-called *Palæaster* to which we could obtain access, including some forms named in MS. by the late Mr Salter, with the following result. The described species are—

Palæaster asperrimus, Salter.
,, *coronella*, ,,
,, *imbricatus*, ,,
,, *obtusus*, Forbes—

two other forms—*P. hirudo*, Forbes, and *P. Ruthveni*, Forbes —being now referred to the genus *Urasterella*, M'Coy.

(*a*) *Palæaster asperrimus*, Salter, is an unsatisfactory species. The specimens in the Museum of Practical Geology have the large transverse ossicles very apparent; but as to whether there is a row inside or outside these, or both, we are by no means certain. It appears, however, to have possessed only four rows.

(*b*) *P. coronella*, Salter. According to its description, the upper surface only of this species is known. We have not seen the ambulacral surface.

(*c*) *P. imbricatus*, Salter. The lower surface of this is likewise unknown. The specimen which serves as the type may be almost looked upon as worthless from a specific point of view.

(*d*) *P. obtusus*, Forbes, has decidedly only four rows of plates on the ambulacral surface of the arms, and is in consequence not a *Palæaster*, as defined by Hall. The large arm-plates are strongly punctate, and the small ambulacral plates contracted in the middle and expanded at the sides.

To sum up: we have one species not referable to *Palæaster;* one of which the structure is rather doubtful, but which is probably congeneric with the first; and two of which the ambulacral structure is unknown.

For those forms possessing only four rows of plates on the ambulacral surface of the arms, including the two species discovered by Mrs Gray at Girvan, with *P. obtusus*, Forbes, and probably *P. asperrimus*, Salter, we are in want of a generic name,—provided none of the hitherto described genera will admit them.

Before entering on this subject, however, it will be well to point out that we do possess, in our Silurian rocks, at least one species of true *Palæaster*—viz., *P. Caractaci*, named, but not described, by Salter.[1] We have examined admirable specimens of this species in the Museum of Practical Geology and the British Museum; and there are, without doubt, six rows of plates on the ambulacral surface of the arms.

In examining the characters of the numerous genera which have from time to time been proposed for Palæozoic Star-fishes, whether of the Asteroid or Ophiuroid type, we may at once dismiss the multiradiate genera, such as—

Lepidaster, Forbes, 1850.
Helianthaster, F. Roemer, 1864.
Eucladia, H. Woodward, 1867.
Trichotaster, Wright, 1873.

Neither in the Girvan forms about to be described, nor in the

[1] Cat. Foss. Mus. Pract. Geol., 1865, p. 30.

British forms referred to *Palæaster*, is there the slightest sign of a disc connecting the arms; we may therefore dismiss at once all those genera so provided—viz.:

Protaster, Forbes, 1849.
Aspidosoma, Goldfuss, 1848.
Palasterina, M'Coy, 1851.
Palæocoma, Salter, 1857 (*non* D'Orb.)
Rhopalocoma, „ „
Palæodiscus, „ „
Schænaster, Meek and Worthen, 1860.
Eugaster, Hall, 1867.
Ptilonaster, „ „
Alepidaster, Meek, 1872.

We may next dismiss those genera in the organisation of which there are special characters entirely separating them from the forms now under discussion, viz.:—

Glyptaster, Hall, 1852.[1]
Edrioaster, Billings, 1858.
Onychaster, Meek and Worthen, 1860.

Three other genera may be eliminated, either from their ventral surface being totally unknown, or from their general structure so little ascertained that a comparison is unnecessary.

Cribellites, G. Tate.
Cœlaster, G. and F. Sandberger (*non* Agassiz, *nec* D'Orb.)
Calliaster, Trautschold, 1879.

Finally, we come to those genera after the type of *Palæaster*, Hall, in which the arms are five in number, no disc uniting these arms, and the ambulacral surface being composed of a variable number of rows of plates, from two to six, irrespective of scattered disc-plates. *Palæaster* we have already considered. Like it, the genus *Petraster*, Billings,[2] possesses six rows of plates on the lower surface of the arms, these being similarly arranged: according to Hall, it is only an abnormal *Palæaster*. The genus *Argaster* generally resembles the former, but has five instead of six rows of plates—viz., two rows of

[1] May be the remains of a Crinoid.
[2] Geol. Survey Canada, Dec. 3, 1858, p. 79.

very large marginal pieces, the usual adambulacral plates, and a single row of ambulacral ossicles.

In the genus *Urasterella*, M'Coy, the skeleton on the ventral side of the arms appears to be of a very simple description—merely two rows of ossicles bordering the ambulacral grooves. *Stenaster*, Billings, is also described[1] as possessing only two rows of large plates bordering the avenues, one on each side. It has been regarded by Hall and Meek as identical with *Urasterella*, M'Coy. Another genus, *Tæniaster*, Billings, has four rows of plates on the ventral surface of each arm, and so far corresponds to our Silurian species; but the ambulacral plates are of a peculiar form, being constricted in the middle. Hall states that a disc exists in *Tæniaster*, and that it is probably identical with *Protaster*, Forbes.

One of the peculiar forms described by Salter, *Bdellocoma*, is said to have six rows of plates like *Palæaster*, but arranged as in *Palæocoma*, Salter, and without any trace of the disc of the latter. The ambulacral ossicles are much contracted.

The Devonian *Archasterias*, J. Müller, is a particularly interesting genus from its close approximation to *Palæaster*, Hall. The ambulacral surface of the arms, as in the latter, appears to be composed of six rows of plates, the ambulacral plates themselves being the smallest, and set alternately in two rows. According to Zittel, the two genera are probably identical. Lastly, in *Xenaster*, Simonowitch, six rows of plates form again the order of arrangement, accompanied by numerous intercalated disc-plates between, and about the bases of the arms. Now, the complexity of the arm-plates in *Palæaster*, *Petraster*, *Argaster*, *Bdellocoma*, *Archasterias*, and *Xenaster*, and the equal simplicity of them in *Urasterella* (=*Stenaster*, Billings), quite forbids the reference to either of them of the four-rowed Girvan and other similar British forms. We still have Billings's *Tæniaster*, which has four rows of plates as in our specimens; but, unfortunately, Hall has thrown doubt over the nature of this Star-fish by asserting that in Billings's very

[1] Ibid., p. 97.

type-specimens a disc occurs, which would give to the genus a totally different appearance to that presented by the British examples under discussion, otherwise we should have been glad to have adopted Mr Billings's genus for the latter.

We are unable to place the Star-fishes from Girvan in any of the genera just mentioned, and are therefore constrained to propose for them, with *Palæaster obtusus*, Forbes, and probably *P. asperrimus*, Salter, the generic name of *Tetraster*.

Genus TETRASTER, Etheridge jun., and Nicholson (*gen. nov.*)

Palæaster, Salter, *et auct.* (*non* J. Hall).

Gen. char.—Body convex to depressed-convex, five-rayed; upper surface of the arms composed of three or more rows of plates, bearing tubercles or spines, close set or scattered; ventral or ambulacral surface composed of four rows of plates, two on each side. Avenues deep, occupied by the two series of ambulacral ossicles, bordered by the two rows of marginal pieces, one row on each side. Arms themselves long or short, becoming broad or somewhat petaloid in the latter form.

Obs.—This genus is closely allied to *Palæaster*, Hall, and has the general appearance of the latter, but differs from it in the structure of the ventral portion of the arms, as previously stated. *Tæniaster* would perhaps have sufficed had not Hall stated that it possessed a disc, which would at once throw it out of our category. The points of difference between it and the foregoing genera will be obvious when the structure of the following species is compared with the remarks on the former given a few pages back.

Tetraster Wyville-Thomsoni, Eth. jun., and Nich. (*sp. nov.*)

(Pl. XXI., figs. 1-8.)

Spec. char.—Body stellate, convex when perfect; arms short, broad, wedge-shaped, non-petaloid, and tapering to an obtusely rounded point, with straight sides. Avenues deep and wide,

continuous to the mouth, not arched over with plates at their upper ends. The bordering rows of plates, eight to nine in number, on the ventral surface of the arms, are large, transverse, and elongated, becoming smaller towards the apex, and with a punctate structure; the ambulacral plates are small, narrow, and pointed at their outer extremities. Apertures between the ambulacral plates large and circular.

Obs.—The affinities of the species are clearly with *T. obtusus*, Forbes, *sp.*, from which it differs in two essential points. In the first place, the arms are obtusely wedge-shaped, instead of lanceolate or petal-shaped, as in Forbes's species, so altering the general appearance in a very marked manner. Secondly, in the specimens examined by us the avenues are open and continuous to the central depression of the mouth, and are not in any way bridged over by any of the plates, so far as we have been able to ascertain, as is the case in *T. obtusus;* and furthermore, the avenues are moderately broad, instead of being narrow.

The specimens are all preserved as casts, from which we have been able to take excellent wax reliefs, showing all the characters in detail: most of the examples are fragmentary, but one or two are entire. It affords us much pleasure to name this after Sir Wyville Thomson, F.R.S., who, with the late Mr J. W. Salter, was one of the earliest investigators of the Girvan Silurian Fauna.

Loc. and Horizon.—Thraive Glen, in a highly fossiliferous rock. (Gray Collection.)

Tetraster, *sp. ind.*

(Pl. XXI., figs. 9 and 10.)

Spec. char.—Body stellate, with slowly tapering arms, which increase little in width throughout their whole length; upper surface unknown, but the body was convex and probably granular. Avenues of the arms broad, and not bridged over by any of the plates; marginal ambulacral plates moderately

convex, transversely elongated, or oblong in form, and less in width than the ambulacral plates; those in the angles of the rays are the largest, and somewhat more elongated than the others; oral plates not visible. The ambulacral plates are also oblong in form, and of regular shape, from sixteen to eighteen in each series; pores of medium size, set laterally at the sides of the ambulacra. Total length of arms, 16 mm.

Obs.—We are, unfortunately, only in possession of a single example of the form; but the much larger size and different proportions at once separate it from the preceding species. The arms are much longer and straighter, and the plates of the ambulacra more nearly equal.

In some of its characters it approaches very closely to *T.* (*?*) *asperrimus*, Salter, *sp.;* but as we have no definite proof of the existence of the remarkable asperities of the upper surface visible in the latter, we prefer to retain the two forms separate —the more so as we have not seen any trace of the prominent spines attached to the marginal plates of the ambulacra of *T.* (*?*) *asperrimus.*

Loc. and Horizon.—Thraive Glen, as before.

Order CRINOIDEA.

The encrinital remains of the Girvan Silurian area are of a very fragmentary and unsatisfactory nature, and consist principally of portions of the column of attachment. Entire calices have been met with at two localities only, Craighead and Penkill, and a few scattered, although well-marked plates, in the conglomerate at Balcletchie. The only species hitherto recognised with any degree of certainty is the *Glyptocrinus basalis*, M'Coy;[1] but as this identification has hitherto depended upon the determination of stems only, it may be looked upon as open to doubt. The localities which have yielded the remains of Crinoidea are :—

[1] Cat. W. Scot. Foss. 1876, p. 15.

1. *Craighead.*—In the limestone and shale; calices and portions of stems.
2. *Penkill.*—In the bluish-grey fossiliferous rock of that locality; calices and portions of stems.
3. *Balcletchie.*—In the dark fossiliferous mudstone; portions of stems. In the conglomerate; separate plates of the calyx.
4. *Shalloch Mill.*—In the fossiliferous shale; portions of stems.
5. *Woodland Point.* — In shale with *Encrinurus punctatus;* fragments of stems.
6. *Bargany Pond burn.*—In shale; fragments of stems.

A few of the stem-fragments are of a sufficiently marked character to be worthy of separate notice, their ultimate identification being probable.

The first of these is a pentagonal stem (Pl. XXII., fig. 1), with flat and straight sides. The component ossicles are thin, equal, or subequal and regular, and, when viewed horizontally, with an inner marked pentagonal zone. Canal circular. Craighead limestone.

The second stem is quadrangular (Pl. XXII., fig. 2), small, with the opposite sides equal, two and two, but very unequal to one another. The sides are a little concave, with an indistinct ridge running down the centre, which arises from a projection of the lateral centre of each ossicle. Ossicles alternately larger and smaller, the larger ones with a single indistinct tubercle at the four angles. Canal small; the transverse section of the ossicles exhibits on the surface of each, four ridges proceeding from the edge of the canal to the sides of the column, one to each of the four projections at the side of each ossicle previously mentioned. Craighead limestone.

A third stem is composed of thick, bony, outwardly rounded, circular ossicles, each one tapering above and below, so that the articular surface is of much less diameter than the general periphery, the union of every two ossicles giving rise to an interposed plain space (Pl. XXII., figs. 3 and 4). Canal pen-

tagonal; articular surface striated. There appears to be a certain variation in this description of stem—in the form and succession of the ossicles: all, however, will probably be included under the one form. The interspaces of less diameter are broad or narrow, plain or finely striated. Craighead and Penkill.

A fourth, and by far the most common Crinoid stem, in the Girvan district, is large, plain, and circular, composed of equal, regular, close-fitting, unornamented ossicles, with the articular surfaces a little biconcave and finely striated radiately. Craighead, Balcletchie, Penkill, &c. (Pl. XXII., fig. 5).

Another form of stem is composed of ossicles larger and smaller alternately, either quite plain, or the larger ones ornamented with a circlet of tubercles. Section oval, canal large, its margins with articular striæ. Penkill, Balcletchie (Pl. XXII., figs. 6, 7, and 8).

Another form of the stem occurs at Balcletchie, in which the ornamenting tubercles are replaced partially by side arms.

Numerous other varieties of stem might be quoted from the Girvan district; but as they are by themselves, generally speaking, undeterminable, they need not be noticed, with one exception—described hereafter.

We may now pass to a description of the entire or partially entire calices which have been obtained by Mrs Gray.

Genus Glyptocrinus, Hall, 1847.

Glyptocrinus, Hall, Pal. N. York, 1847, i. p. 281.
„ Billings, Fig. and Descrip. Canadian Org. Remains, Dec. 4, 1859, p. 55.

Obs.—The calyx in this genus is either pyriform, oval, or globular, and in some of its species very large. The column is also large, usually round, and strongly annulated or moniliform. The plates composing the calyx are flat, thin, and smooth, or ornamented with radiating ridges, striæ, or raised margins. The basal plates are five, and either pentagonal or hexagonal. The primary radials are large pentag-

onal plates, the secondary hexagonal in form, and the tertiary heptagonal. The regular inter-radials are usually six in number, but those of the azygous inter-radius, or anal side, are seven or more. In addition to the striæ or ridges ornamenting the individual plates, the surface of the calyx is traversed by five prominent ridges, which, taking their origin from the primary radial plates, cross the secondary plates of the same name, and bifurcate on the tertiary, the divisions extending to the base of each pair of arms. (Hall and Billings.)

Throughout the whole Silurian area of the southern uplands of Scotland, at certain horizons the casts of scattered and strongly annulated stem-rings are common, which in all probability are those of this genus.

Glyptocrinus (?) ***sp. ind.***

(Pl. XXII., figs. 9-11.)

Obs.—In no case have we more than about half of the calyx or cup of this Crinoid preserved; and what there is presented to us, is in that indistinct state which renders determination doubly difficult.

The arrangement of the plates appears to be that of *Glyptocrinus*, in so far as the basal plates, first, second, and third radials, and certain of the inter-radials are concerned. Here, however, in every case, the calices are broken off, and the further superposition of the plates is unknown. The individual pieces composing the calices are thicker and much more convex than is usually found to be the case in *Glyptocrinus*, and their conversion into that peculiar form of calcite so frequently met with in the remains of the Palæozoic Echinodermata has quite obliterated the surface ornamentation which usually is present in the species of this genus. Notwithstanding this, however, the five great radial ridges, which take their rise at the primary radials, extend to the tertiary radials, and there bifurcate, are still perceptible. The late Mr J. W. Salter proposed the separation of *G. basalis*, M'Coy, one of our British

species, from the genus as defined by Prof. Hall, on account of the presence of parabasal plates.[1] This, if a sound generic character, and not one of an advanced specific nature, will doubtless recommend itself; but so far as our observation has gone, the Girvan forms do not possess these parabasals, and will fall directly into the genus *Glyptocrinus* itself.

We believe, provided our reference to *Glyptocrinus* be correct, that the Girvan forms are specifically distinct from any hitherto described, both in the form and size of the calyx, and in that of the constituent plates. We would, in this case, propose for it the name of *G. globularis*, in allusion to the globular form of the cup or calyx.

Loc. and Horizon.—Craighead, in the shale of the Craighead limestone; common. (Gray Collection.)

The only other remain of *Glyptocrinus* we have to refer to is a specimen from Thraive Glen (Pl. XXII., fig. 12),—an example of the upper part of the cup, with portions of the arms, from which the integument has been removed, leaving an internal cast of the parts. The markings representing the divisions of the plates are but indistinctly seen. The segmentation of the arms, however, is very well shown, as are also the ridges proceeding from the base of the latter over the calyx.

Loc. and Horizon.—Thraive Glen, in a highly fossiliferous liver-coloured sandstone. (Gray Collection.)

Genus Myelodactylus, Hall, 1852.

Myelodactylus, Hall, Pal. N. York, 1852, ii. p. 191.
Ophiocrinus, Charlesworth (MS.), Coll. Brit. Mus. (*non* Angelin, *nec* Semper).
Herpetocrinus, Salter, Cat. Camb. Sil. Foss., Woodw. Mus. Cambridge, 1873, p. 118.

Obs.—This name was proposed to include what Prof. Hall took to be the arms and fingers of a Crinoid, "the remarkable feature of which is the foramen or medullary canal penetrating the column of joints,—a character not existing in the species

[1] Mem. Geol. Survey, iii. p. 283.

where the fingers are composed of a double series of joints, and which is not conspicuous in the simple jointed fingers without tentacula."

The remains of this organism consist of thin, wide, flat joints, always curved in the same direction, and sometimes tightly wound in successive coils. The united joints are curved convexly on the outer side or back of each coil, where they are sometimes slightly tubercular and occasionally ridged, whilst on the inside the coils are concave. Each plate or ossicle is, in fact, semicircular, or, more properly speaking, crescentiform, and "penetrated vertically by an oblong quadrangular canal:" the two extremities of each crescent are truncated. The articulating surface is of a complex structure. (Hall.)

Myelodactylus convolutus, Hall, consists of a series of these joints united together, and tightly wound into successive close-fitting coils, the convex back of one coil adjusting itself to the concave inner surface of that preceding it. The so-called "tentacula" are attached only to the edges of the inner side. As before stated, these were believed by Prof. Hall to be the arms and fingers of a Crinoid.

In 1873, the late Mr J. W. Salter's posthumous genus *Herpetocrinus* was published,[1] which is stated to be identical with *Myelodactylus*, Hall, and was proposed for it, as "the name based on false ideas cannot be kept." All Mr Salter says of his genus is as follows: "A minute cup, all but obsolete, and with dichotomous narrow arms, branched like those of *Homocrinus*, Hall. This is set on a narrow cylindrical sub-erect stem, which soon, however, becomes compressed, then hollowed on one side, and bears close-set axillary arms to the lowest part, so far as observed. The stems, coiled up like an adder, resemble arms of Crinoids rather than stems." This description, coupled with the figure given by Mr Salter, renders it quite evident that *Myelodactylus*, Hall, and *Herpetocrinus*, Salter, are identical.

We possess, from Girvan (Pl. XXI., figs. 11 and 12), certain

[1] Cat. Camb. Sil. Foss., Woodw. Mus. Cambridge, p. 118.

fragments, which, although in no way presenting a complete coil, as in *M. convolutus*, or a perfect example, as in the figure[1] of *H. Fletcheri*, still possess all the characters assigned to the former by Hall, when examined in fragments. In the first place, there occur at two localities portions, and almost complete circles or coils, of ossicles, forming crinoid stems, sometimes bearing small axillary stems attached to the inner edge of the coil (Pl. XXI., fig. 12), exactly as in Hall's *Myelodactylus*. These imperfect specimens are composed of a large number of thin semicircular ossicles, so shaped as to form, when united together, a strong ridge or keel on the outer side, and on which the sutures between the respective ossicles are more strongly marked than on the sides. The largest and best preserved of our specimens clearly shows traces of the concave inner side. Our specimens appear to represent two species, the axillary arms previously mentioned being visible in one of them only. We do not consider Hall's having mistaken stems for arms as a sufficient reason for the rejection of his name, and therefore adopt it in preference to Mr Salter's. If every name in palæontology based on a false idea is to be abandoned in place of a subsequently proposed one when properly and correctly defined, confusion will be endless. Numbers of cases could be cited in which names given on an erroneous interpretation of structure are retained by our best authorities.

The British Museum collection contains several instances of these coiled-up stems from Dudley, to which the MS. name *Ophiocrinus*, Charlesworth, is attached. Mr Edward Charlesworth, F.G.S., has kindly informed us that this name was proposed by him for these strange Crinoids about fourteen years ago, at one of the meetings of the Birmingham Natural History Society; but so far as he is aware, his description has never been published. Be that as it may, we suspect it is identical with the much earlier proposed *Myelodactylus*, Hall. The name *Ophiocrinus* has also been made use of by both Angelin and Semper.

[1] Is not this a restoration?

Myelodactylus, *sp.* (or *sps.* ?) *ind.*

(Pl. xxi., figs. 11 and 12.)

Loc. and Horizon.—In the grey fossiliferous mudstone of Penkill; in the dark greenish-blue fossiliferous mudstone of Balcletchie (?). (Gray Collection.)

In addition to the fragmentary remains of Crinoidea just described, the Balcletchie conglomerate has yielded a few small perisomatic plates, in regard to the affinities of which we are somewhat doubtful. They may only be those of a Crinoid with highly ornate plates, or, on the other hand, those of a Cystidean. The plates in question (Pl. xxii., figs. 13-19), are small pentagonal or hexagonal flattened bodies, having on their exterior surfaces ridges radiating from the centre of the plates, and arranged in zones or groups, as so frequently seen on the surface of those of the Cystoidea.

In one plate these ridges are coarse and few in number; in another, much finer, and in better defined groups, with a plain central space, somewhat elevated above the general surface, and giving off flexuous branches which separate the groups of striæ (Pl. xxii., fig. 13). Other forms are present, but in too indistinct a state of preservation for description. One or two specimens show what appear to be the interior of these plates; but of which kind, it is impossible to say. Here the surface is smooth and plain, a little concave, and with five double rows of minute pits or punctæ (Pl. xxii., fig. 18), each double row radiating from the centre to one of the angles of the pentagon. In a single instance there are only four of these double rows of pits (Pl. xxii., fig. 19).

We have not observed any trace of plates bearing the characteristic pectinated rhombs, or hydrospires, of the Cystoidea; and it is within the bounds of possibility that, supposing these to be the plates of Echinoderms of this order, the latter may have belonged to that section in which the pectinated rhombs are represented by pores or fissures scattered without definite

order over the plates of the body or calyx; and further, that the pores just described may bear some relation to the hydrospires. This is borne out by the appearance of another plate, not previously referred to, in which some of the coarse ridges have become abraded, and are now visible as elongated fissures.

In fact, that this is the case is, we think, tolerably clear from the structure of a fourth specimen, in which the pores are visible penetrating through to the exterior, as a circlet round the central smooth portion of the plate, and then, as in the former case, when viewed from the interior, forming five or six double radii.

Lastly, another form of ornamented plate in the Balcletchie conglomerate consists of one having a central point, from which four radii proceed. These radii, or ridges, are joined one to another by straight ornamenting lines parallel to the margins of the plate, producing a square figure.

In taking into consideration the affinity of these plates, it must not be forgotten that the late Mr J. W. Salter described minute sharp tubercles on the interior of the plates of *Glyptocrinus*, but which in no way gave rise to perforations. They are placed "along the edges, or at the angles of the plates, or more commonly still on either side of the faint radiating ridges."[1] As seen in the casts, he compares them to the surface pores of the *Sphæronites*.

So far as we can see, these little plates from Girvan appear to have more in common with the Cystoidea than the Crinoidea.

[1] Mem. Geol. Survey, iii. p. 283.

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The names in ordinary type are those described in the present work.
Those in *italics* are synonyms.
Those with an asterisk (*) prefixed are merely referred to in illustration of remarks.

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END OF THE FIRST VOLUME.

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PLATE XVI

PLATE XVI.

Fig. 1. Small specimen of *Heliolites interstincta*, Linn., from Woodland Point, Girvan, of the natural size.

Fig. 1 *a*. Tangential section of the same, enlarged five times, showing well-developed septa in the large corallites.

Fig. 1 *b*. Vertical section of the same, enlarged five times, showing the deeply concave tabulæ of the large tubes.

Fig. 2. Tangential section of an example of *Heliolites interstincta*, Linn., from the Wenlock Limestone of Stoke-Edith, enlarged five times, showing the well-developed and irregularly anastomosing septa of the large corallites. *Coll.* H. A. Nicholson.

Fig. 2 *a*. Vertical section of the same specimen, enlarged five times, showing the horizontal and comparatively remote tabulæ. Traces of the septa are also seen in the interior of the large corallites.

Fig. 2 *b*. Transverse section of a single large corallite of the same specimen, with a single encircling zone of small corallites, enlarged twenty times, showing the reticulated septa.

Fig. 3. Tangential section of an example of *Heliolites interstincta*, Linn., from the Wenlock Limestone of Gotland, enlarged five times, showing the comparatively large size of the larger corallites, and their quite rudimentary septa. *Coll.* H. A. Nicholson.

Fig. 3 *a*. Vertical section of the same specimen, enlarged five times, showing the crowded and anastomosing tabulæ of the large corallites.

Fig. 4. Tangential section of a specimen of *Heliolites interstincta*, Linn., from the Wenlock Limestone of Stoke-Edith, enlarged five times, showing the rudimentary condition of the septa. The large corallites are somewhat smaller than in fig. 3. *Coll.* H. A. Nicholson.

Fig. 4 *a*. Vertical section of the same specimen, enlarged five times. The tabulæ of the large tubes differ from those of fig. 3 *a* in being comparatively remote.

Fig. 5. Vertical section of the shell of a Gasteropod covered with a colony of *Heliolites* (?) *parasitica*, Nich. and Eth. jun., enlarged twice. Mulloch Hill, Girvan.

Fig. 5 *a*. Tangential section of the corallum of *H.* (?) *parasitica*, enlarged five times. Mulloch Hill, Girvan.

Fig. 5 *b*. Vertical section of the same corallum, similarly enlarged.

Fig. 6. An imperfect specimen of *Heliolites foliacea*, Nich. and Eth. jun., from Woodland Point, Girvan, of the natural size. The under surface of the corallum is adherent to the matrix.

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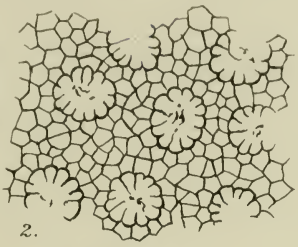
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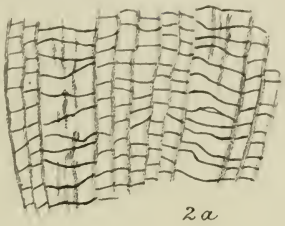
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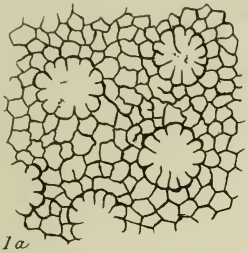
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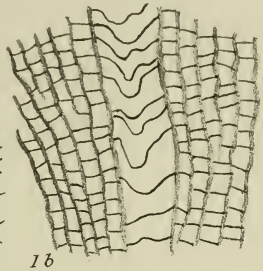
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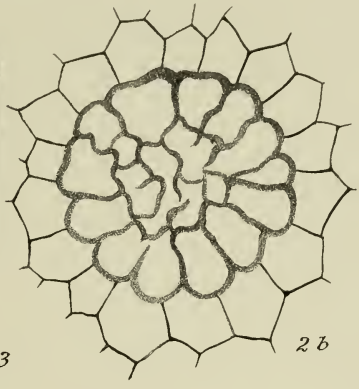
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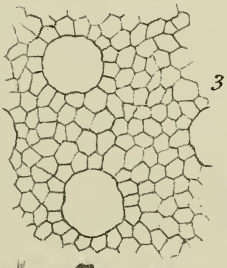
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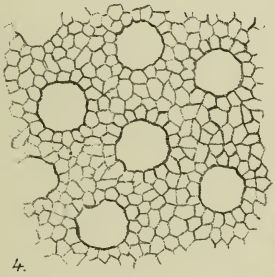
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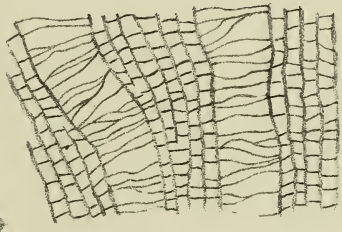
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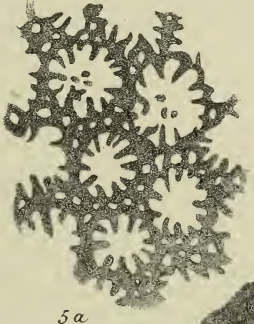
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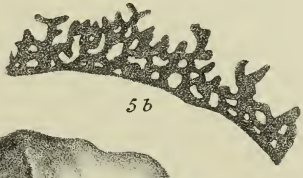
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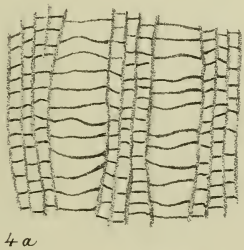
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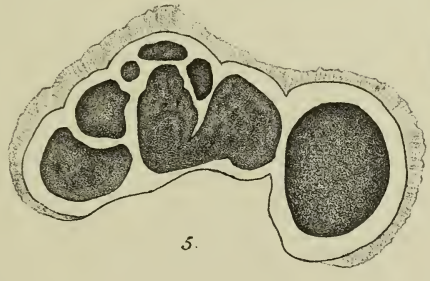
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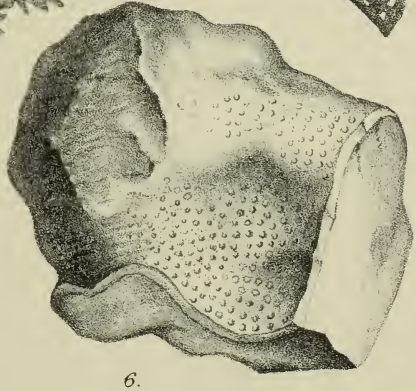
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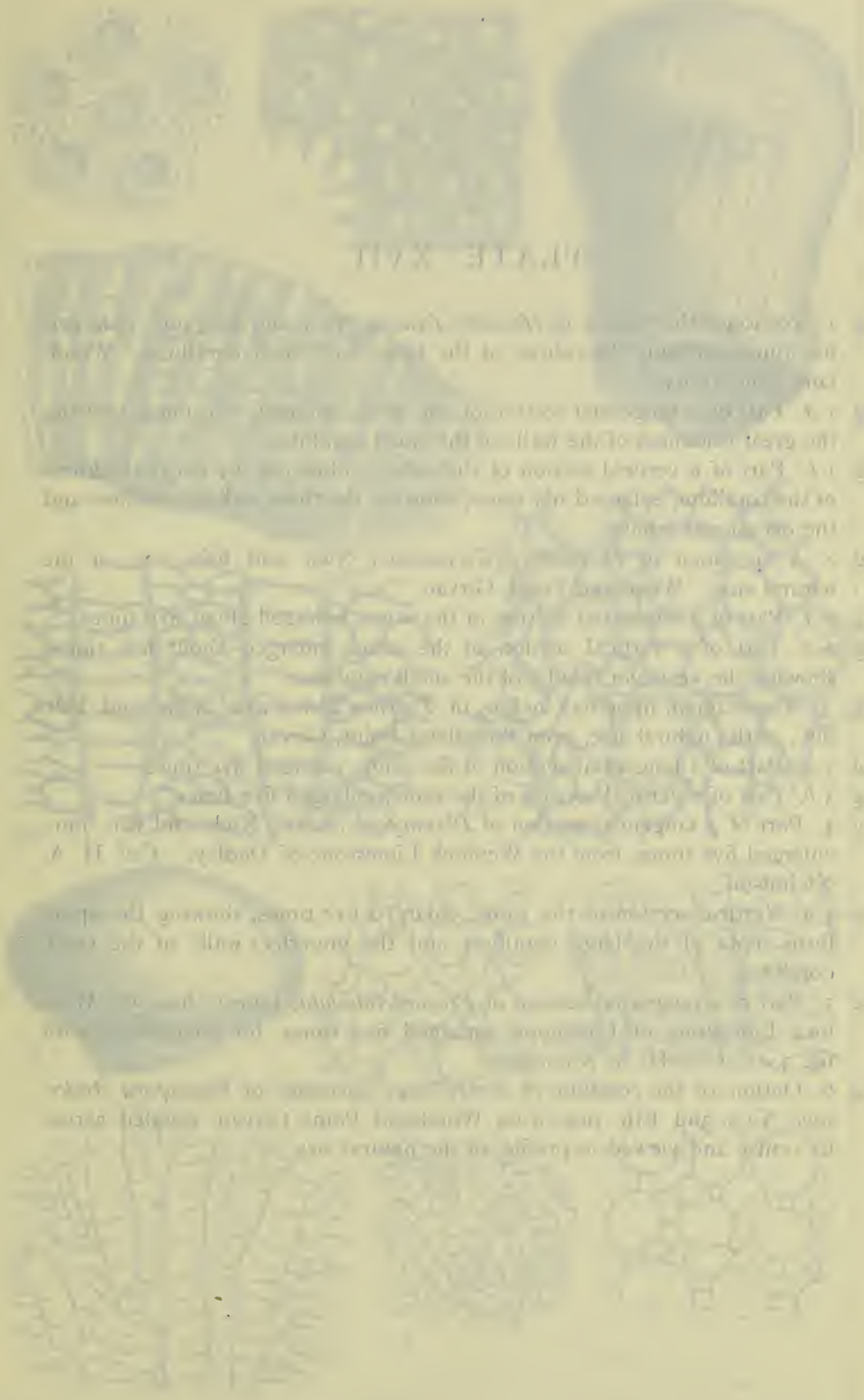


PLATE XVII.

Fig. 1. Portion of the surface of *Heliolites foliacea*, Nich. and Eth. jun., enlarged five times, showing the calices of the large and small corallites. Woodland Point, Girvan.

Fig. 1 *a*. Part of a tangential section of the same, enlarged ten times, showing the great thickness of the walls of the small corallites.

Fig. 1 *b*. Part of a vertical section of the same, embracing the entire thickness of the corallum, enlarged ten times, showing the thick-walled corallites and the occasional tabulæ.

Fig. 2. A specimen of *Plasmopora Girvanensis*, Nich. and Eth. jun., of the natural size. Woodland Point, Girvan.

Fig. 2 *a*. Part of a tangential section of the same, enlarged about five times.

Fig. 2 *b*. Part of a vertical section of the same, enlarged about five times, showing the vesicular tabulæ of the small corallites.

Fig. 3. A specimen, imperfect below, of *Propora Edwardsii*, Nich. and Eth. jun., of the natural size, from Woodland Point, Girvan.

Fig. 3 *a*. Part of a tangential section of the same, enlarged five times.

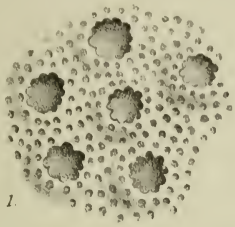
Fig. 3 *b*. Part of a vertical section of the same, enlarged five times.

Fig. 4. Part of a tangential section of *Plasmopora exserta*, Nich. and Eth. jun., enlarged five times, from the Wenlock Limestone of Dudley. *Coll.* H. A. Nicholson.

Fig. 4 *a*. Vertical section of the same, enlarged five times, showing the spiniform septa of the large corallites, and the imperfect walls of the small corallites.

Fig. 5. Part of a tangential section of *Propora tubulata*, Lonsd., from the Wenlock Limestone of Longhope, enlarged five times, for comparison with fig. 3 *a*. *Coll.* H. A. Nicholson.

Fig. 6. Outline of the corallum of a very large specimen of *Pinacopora Andersoni*, Nich. and Eth. jun., from Woodland Point, Girvan, divided across its centre and viewed in profile, of the natural size.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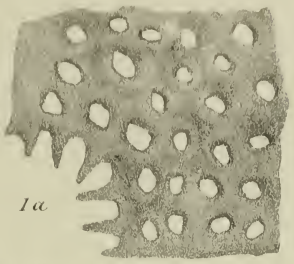
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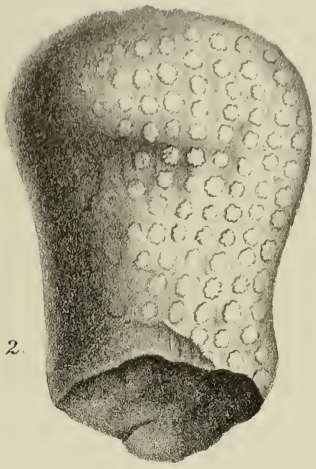
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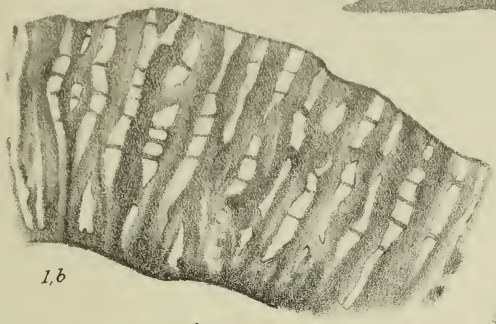
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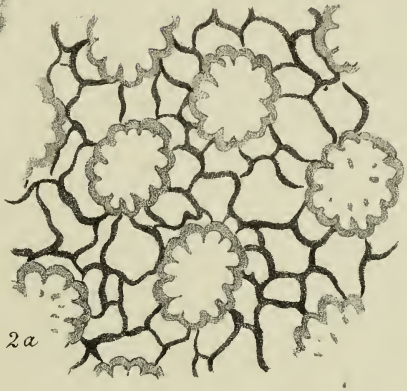
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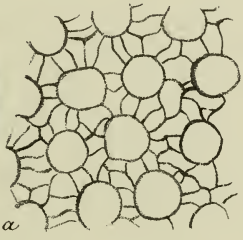
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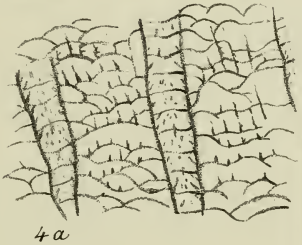
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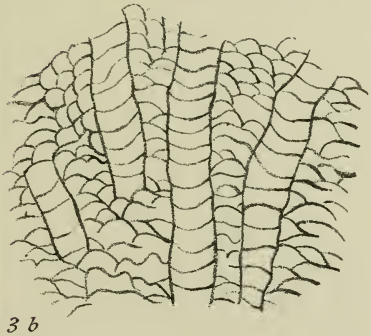
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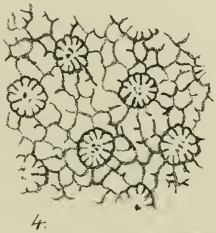
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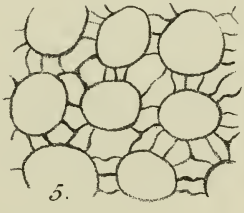
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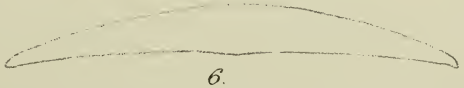
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PLATE XVIII

PLATE XVIII.

Fig. 1. Under surface of a very large specimen of *Pinacopora Andersoni*, Nich. and Eth. jun., from Woodland Point, Girvan, of the natural size, showing the concentrically striated basal epitheca. The specimen is the same as that shown in elevation in fig. 6, Plate XVII.

Fig. 1 *a*. A small portion of the upper surface of the same, enlarged about five times, showing the large calices, with their rudimentary septa.

Fig. 1 *b*. Under surface of a very small specimen of the same, of the natural size.

Fig. 1 *c*. Vertical section of the same specimen as the last, of the natural size, showing the form of the corallum.

Fig. 1 *d*. Part of a vertical section of the same species, embracing the entire thickness of the corallum, enlarged about five times, showing the vesicular tabulæ of the small corallites.

Fig. 1 *e*. Part of another vertical section of the same, showing that the tabulæ of the small corallites are in places horizontal and in places vesicular, and that they are continued to a point much nearer the surface than is the case with the horizontal tabulæ of the large corallites.

Fig. 2. Transverse section of part of the corallum of *Halysites*, sp., allied to *H. catenularia*, but wanting small tubes intercalated between the larger corallites, enlarged five times. Woodland Point, Girvan.

Fig. 3. Transverse section of *Halysites*, sp., allied to *H. escharoides*, Lam., enlarged five times.

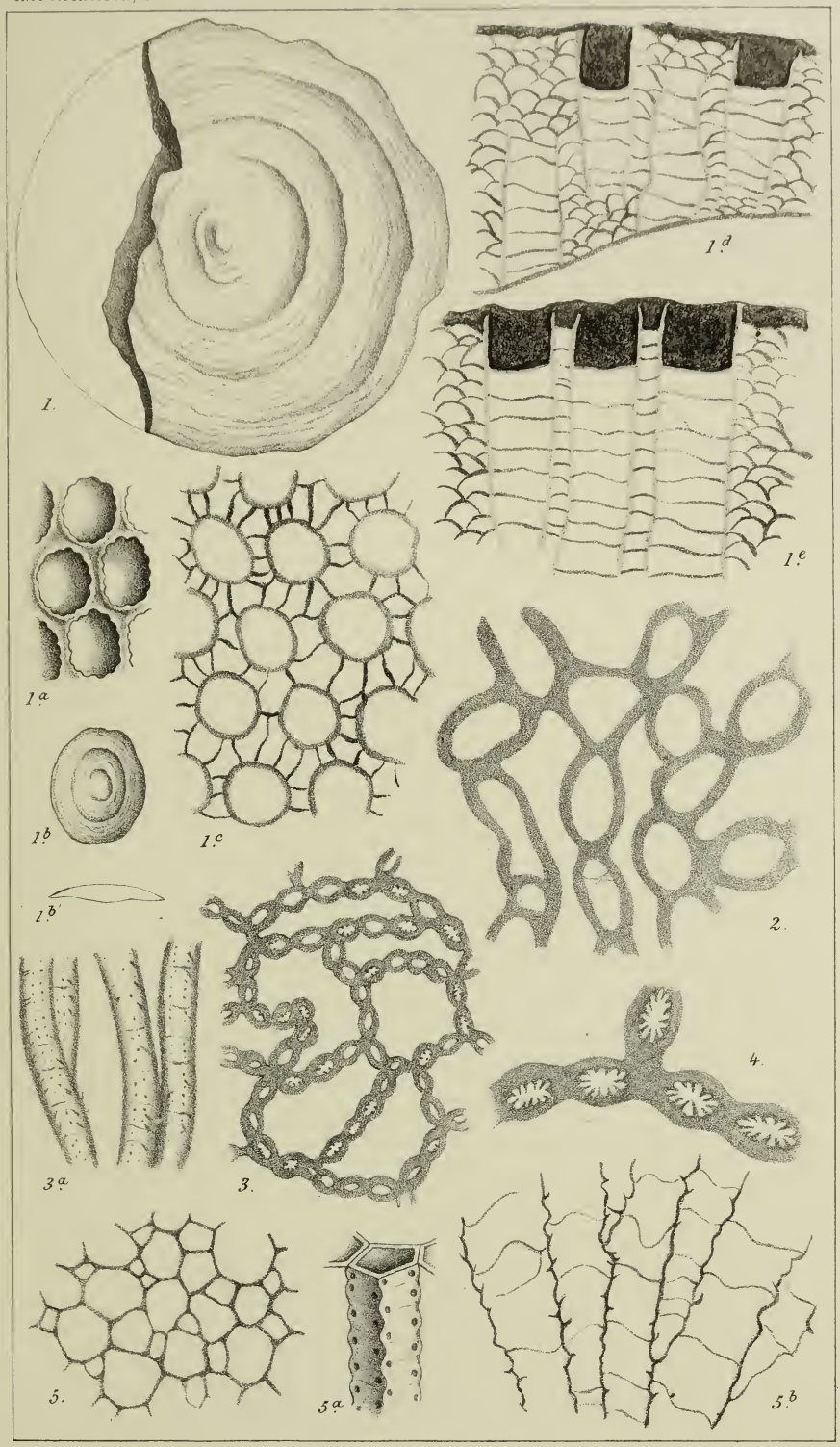
Fig. 3 *a*. Vertical section of a few tubes of the same, showing the cut ends of the spinulose septa. Woodland Point, Girvan.

Fig. 4. Transverse section of *Halysites*, sp., enlarged five times. Cement-stones, Shalloch Mill, Girvan. *Coll.* Charles Lapworth.

Fig. 5. Transverse section of a small specimen of *Favosites Mullochensis*, Nich. and Eth. jun., from Woodland Point, Girvan, enlarged five times.

Fig. 5 *a*. Part of a single corallite of the same, slightly generalised; enlarged to show the arrangement of the mural pores and the undulated walls.

Fig. 5 *b*. Vertical section of the same, enlarged five times, showing the sharply undulated walls and the remote tabulæ. Woodland Point, Girvan.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1.d
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1.a
1.c
1.b
1.b
2.
3.a
3.
4.
5.
5.a
5.b

PLATE XIX.

Fig. 1. Fragment of a mass of limestone traversed by the root-fibres of *Hyalonema Girvanense*, Nich. and Eth. jun., of the natural size. Knockgeerin, near Girvan. *Coll.* C. Lapworth.

Fig. 1 *a*. Transverse section of a portion of the same, enlarged five times. Some of the fibres show the axial canals.

Fig. 1 *b*. Longitudinal section of part of the same, enlarged five times, and cut slightly obliquely as regards the long axes of the fibres. The fibres show, as in the preceding, a great difference in size, while some exhibit the axial canals, and most are traversed by transverse partitions.

Fig. 2. Vertical section of a fragment of *Clathrodictyon vesiculosum*, Nich. and Murie, enlarged twenty-five times, from the Upper Silurian Mudstones of Woodland Point, Girvan.

STAUROCEPHALUS? *sp. ind.*, p. 283.

Fig. 3. The remains of a badly preserved specimen, showing portions of the head, thorax, and pygidium ; × 3.

CYCLOPYGE REDIVIVA, *Barr. sp.*, p. 284.

Fig. 4. An entire example, with the divisions of the body well preserved, from Whitehouse ; × 6.

CYCLOPYGE ARMATA, *Barr. sp.*, p. 286.

Fig. 5. A glabella, retaining a portion of the frontal spine, and with grooves faintly marked. Whitehouse ; × 2.

Fig. 6. Another example from the same locality ; × 2.

Fig. 7. The epistoma and portions of the large confluent eyes. Whitehouse ; × 3.

Fig. 8. A series of the facets of the eyes, highly magnified ; same locality.

TRINUCLEUS MACCONOCHIEI, *Eth. jun.*, and *Nich*, p. 288.

Fig. 9. A cast in wax, taken from the original specimens (see Fasciculus II., t. xiv. f. 1), and showing the constriction at the base of the glabella ; × 4.

TRINUCLEUS, *sp. ind.*, p. 288.

Fig. 10. The glabella, one cheek, and a portion of the punctate fringe of a large *Trinucleus*. Whitehouse—nat. size.

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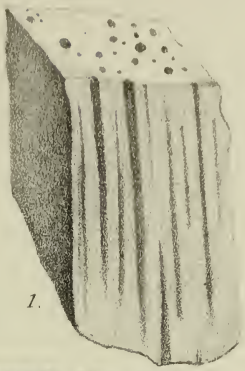
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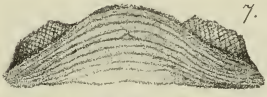
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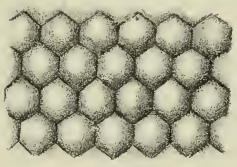
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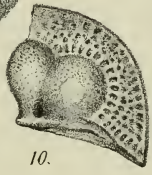
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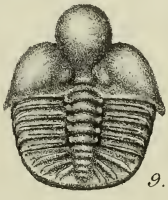
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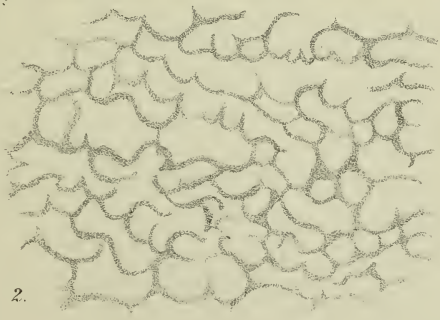
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PLATE XX.

Dunster Lumworthy, Fm. Jm., and Mck., p. 290.

Fig. 1. *Nodosaria* entire individual, showing the semi-circular head-chamber, long pencil-shaped shell, narrow thorax, and generally attenuated form. Whitehouse.—mat. size.

Dunster, *op. inf.*, p. 293.

Fig. 2. *Nodosaria* (or portion of one only?). Whitehouse; × 5.

Dunster, *op. inf.*, p. 293.

Fig. 3. *Nodosaria* much elongated *pyrgidium*? Whitehouse; × 5.

Dunster (?), *op. inf.*, p. 293.

Fig. 4. *Nodosaria* small *pyrgidium* with six segments, and a terminal appendage reaching to the posterior margin; referred with doubt to *Nodosaria*. Whitehouse; × 5.

Dunster (*incertae formae*), p. 295.

Fig. 5. *Nodosaria* small entire example, probably representing an immature form. There are four thoracic somites developed, and a large *pyrgidium*. Whitehouse; × 6.

Agoscelus perrugatus. Barr (?), p. 296.

Fig. 6. *Nodosaria* globella, which appears to possess all the essential characters of this species. The divisions of the globella, including the two basal lobes, are quite apparent, and the radiated check-margin is well shown. Whitehouse; × 6.

Fig. 7. *Nodosaria* minute specimen, which we believe to represent the young of this species. Whitehouse; × 4.

Turritella Peacuti, Mk. Jm., and Mck., p. 301.

Fig. 8. The largest specimen we possess, although fragmentary. The large kite-shaped plates are arranged at right angles to the longer axis. Whitehouse; × 2.

Fig. 9. A much more entire specimen, but smaller than Fig. 8. The gradation of the kite-shaped plates from right angles to nearly parallel in position with the longer axis is well shown. Whitehouse; × 2.

Fig. 10. Another example, somewhat more elongated in form, but possessing the same general characters. Whitehouse; × 2.

See on the Longissimus, Murchison, p. 303.

Fig. 11. A complete and tapering tube of this species from Drammuck—mat. size.

Fig. 12. Another example from the same locality—mat. size.

Trochammina siliciana, var. Bucklandi, Mmr.

Fig. 13. The specimen represented in Pasculus II. (t. xiii. f. 20), referred to show the small "eye-lines" passing through the ocular tubercles; × 2.

PLATE XX.

DIONIDE LAPWORTHI, *Eth. jun.*, and *Nich.*, p. 290.

Fig. 1. An almost entire individual, showing the semicircular head-shield, long genal spines, small glabella, narrow thorax, and generally attenuated body. Whitehouse—nat. size.

DIONIDE, *sp. ind.*, p. 293.

Fig. 2. A pygidium (or portion of one only?). Whitehouse; × 3.

DIONIDE, *sp. ind.*, p. 294.

Fig. 3. A much elongated pygidium? Whitehouse; × 3.

DIONIDE (?), *sp. ind.*, p. 294.

Fig. 4. A small pygidium with six segments and a terminal appendage reaching to the posterior margin; referred with doubt to *Dionide*. Whitehouse; × 8.

DIONIDE (*immature form*), p. 295.

Fig. 5. A small entire example, probably representing an immature form. There are four thoracic somites developed, and a large pygidium. Whitehouse; × 6.

AGNOSTUS PERRUGATUS, *Barr* (?), p. 296.

Fig. 6. A glabella, which appears to possess all the essential characters of this species. The divisions of the glabella, including the two basal lobes, are quite apparent, and the radiated cheek-margin is well shown. Whitehouse; × 6.

Fig. 7. A minute specimen, which we believe to represent the pygidium of this species. Whitehouse; × 4.

TURRILEPAS PEACHII, *Eth. jun.*, and *Nich.*, p. 301.

Fig. 8. The largest specimen we possess, although fragmentary. The large kite-shaped plates are arranged at right angles to the longer axis. Whitehouse; × 2.

Fig. 9. A much more entire specimen, but smaller than Fig. 8. The gradation of the kite-shaped plates from right angles to nearly parallel in position with the longer axis is well shown. Whitehouse; × 2.

Fig. 10. Another example, somewhat more elongated in form, but possessing the same general characters. Whitehouse; × 2.

SERPULITES LONGISSIMUS, *Murchison*, p. 303.

Fig. 12. A compressed tapering tube of this species from Drummuck—nat. size.

Fig. 13. Another example from the same locality—nat. size.

TRINUCLEUS SETICORNIS, *var.* BUCKLANDI, *Barr*.

Fig. 11. The specimen represented in Fasciculus II. (t. xiii. f. 20), refigured to show the small "eye-lines" passing through the ocular tubercles; × 2.

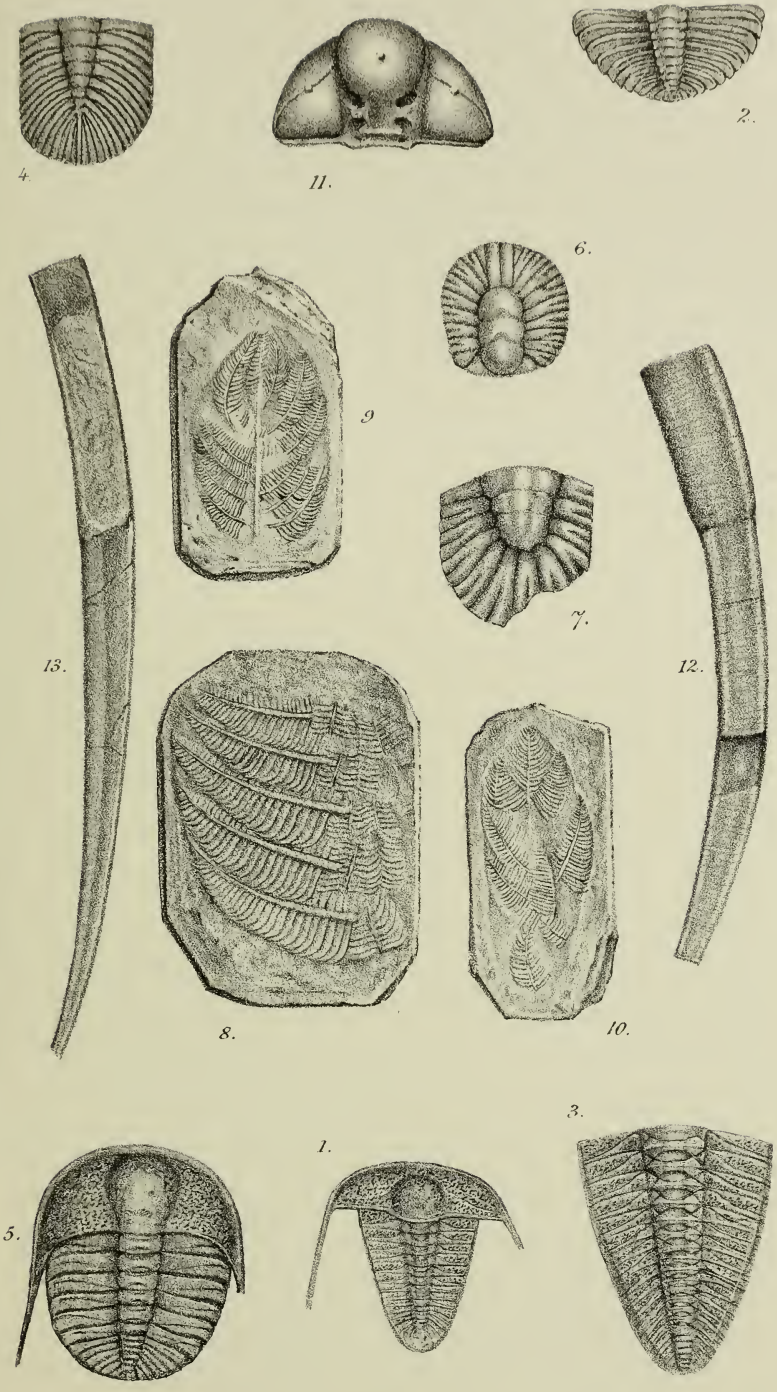

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PLATE XXII.

PLATE XXI.

TETRASTER WYVILLE-THOMSONI, *Æth. jun.*, and *Nich.*, p. 324.

Figs. 1 - 8. Various specimens preserved as casts in the highly fossiliferous deposit of Thraive Glen, showing the general arrangement of the plates.

Figs. 2, 3, 6, and 7 are impressions in wax from the foregoing figures which represent the actual specimens. Figs. 1 and 2, × 3 times; figs. 4-8, × 4 times.

TETRASTER, *sp. ind.*, p. 325.

Fig. 9. A specimen preserved as a cast in the fossiliferous rock of Thraive Glen, with one arm almost entire, and portions of the other four; × 2.

Fig. 10. Wax cast of the same; × 2.

MYELODACTYLUS (?), *sp. ind.*, p. 333.

Fig. 11. Portion of a coiled stem, probably referable to this genus. It is rounded on the convex, and hollowed out on the concave side. Fossiliferous mudstone of Penkill—nat. size.

Fig. 12. Portion of another stem, with the remains of the auxiliary side arms on the concave side. Balcletchie—nat. size.

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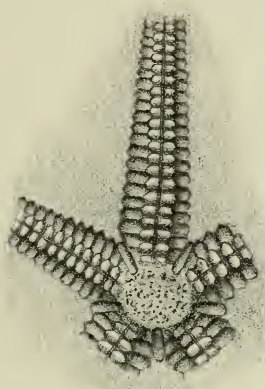

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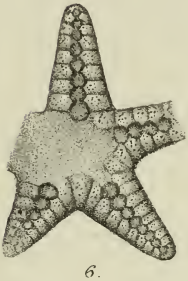

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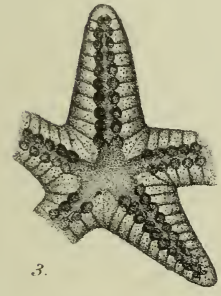

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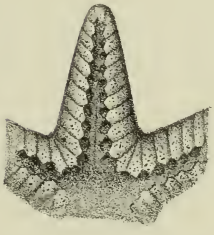

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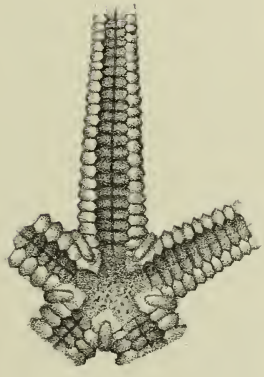

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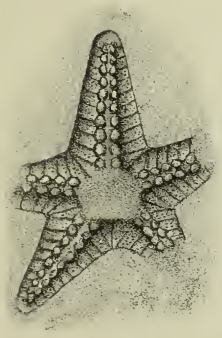

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PLATE XXII.

Crinoids—Trias, pp. 317, 318.

Fig. 1. Small pentagonal stem from the Cockfield Limestone—nat. size.

Fig. 2. Small quadrangular stem, with the cyclosis wider apical, two and two (Conjugated Internodes—enlarged.

Figs. 3 and 4. Stem composed of thin, deep, concave, single and smaller, from the Cockfield Limestone—enlarged, natural.

Fig. 5. A stem common in the Carnian system, composed of large, plain equal, circular and regular joints—nat. size.

Figs. 6, 7, and 8. Varieties of smaller stem, in which the joints are nearly large and small alternately, and sometimes connected with alternate Pentagonal—nat. size.

Echinoderms, p. 319.

Fig. 9. Side view of the lower portion of the calyx, showing the arrangement of the plates and the characteristic rib passing upwards. Enlarged Limestone, Trias.

Figs. 10 and 11. Basal views of other specimens from the same locality.

Crustaceans, p. 332.

Fig. 12. An internal cast, from the lower Keuper rock of Thuringia, of the upper part of the body and head of the same.

Plates of Crustaceans, pp. 332, 333.

Fig. 13. Small plate with a central pore (poriferous), from the Keuper sandstone of the Thuringian district.

Fig. 14. Another plate, in which the pores have become depressions, at the extreme of the intervening portions of the plate.

Figs. 15 and 15a. Small plates, in which the separating ridges terminate in round and non-flexuous.

Fig. 16. A peculiar plate, in which one arm is long in another, from a central point.

Figs. 18 and 19. The interior or two small plates, showing five and four muscular pits of pinnate respectively, corresponding to the points of the plates.

[The remaining figures on Plate 23—in the old plan for Palæontology—are illustrated, and the figures are used on Plate 24.]

PLATE XXII.

CRINOID STEMS, pp. 327, 328.

Fig. 1. Small pentagonal stem from the Craighead Limestone—nat. size.

Fig. 2. Small quadrangular stem, with the opposite sides equal, two and two. Craighead Limestone—enlarged.

Figs. 3 and 4. Stem composed of thick, bony, circular ossicles, larger and smaller, from the Craighead Limestone—somewhat enlarged.

Fig. 5. A stem, common in the Girvan district, composed of large, plain, equal, circular, and regular joints—nat. size.

Figs. 6, 7, and 8. Varieties of another stem, in which the joints are usually larger and smaller alternately, and sometimes ornamented with tubercles. Balcletchie—nat. size.

GLYPTOCRINUS, *sp. ind.*, p. 329.

Fig. 9. Side view of the lower portion of the calyx, showing the arrangement of the plates and the characteristic ribs passing upwards. Craighead Limestone; × 2.

Figs. 10 and 11. Basal views of other specimens from the same horizon; × 2.

GLYPTOCRINUS, *sp. ind.*, p. 330.

Fig. 12. An internal cast, from the fossiliferous rock of Thraive Glen, of the upper part of the calyx and bases of the arms; × 1½.

Plates of CRINOIDEA or CYSTOIDEA, p. 333, 334.

Fig. 13. Small plate with a central plain space, from which radiate seven flexuose ridges: the interspaces are striated outwards.

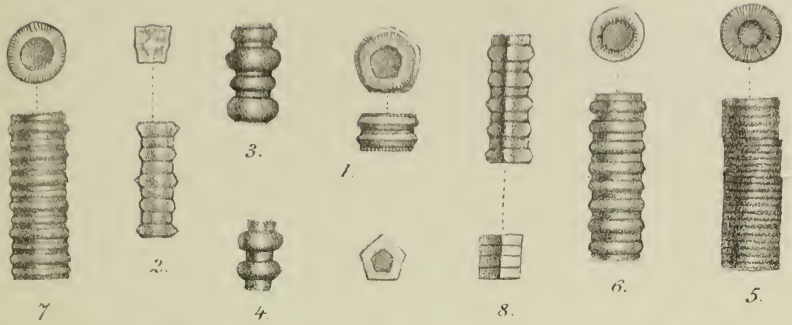
Fig. 14. Another plate, in which the ridges have become broader, at the expense of the intervening portions of the plate.

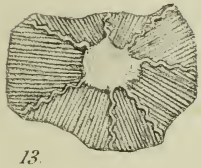
Figs. 15 and 17. Small plates, in which the separating ridges are five in number and non-flexuous.

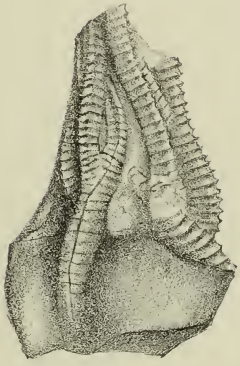
Fig. 16. A peculiar plate, in which the radii are four in number, proceeding from a central point.

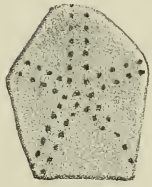
Figs. 18 and 19. The interiors of two small plates, bearing five and four double radiating rows of puncta respectively, proceeding to the angles of the plates.

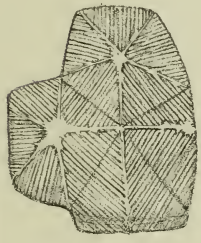
(*The specimens represented by Figs.* 13-19 *are all from the Balcletchie Conglomerate, and the figures are each enlarged four times.*)

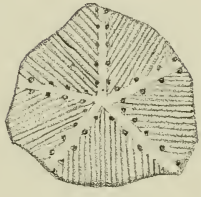


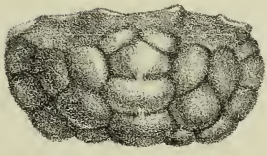


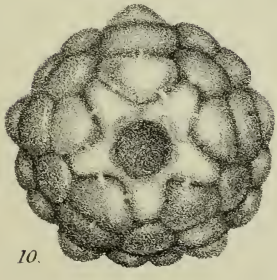


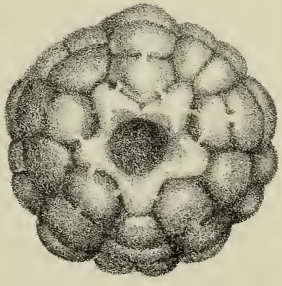












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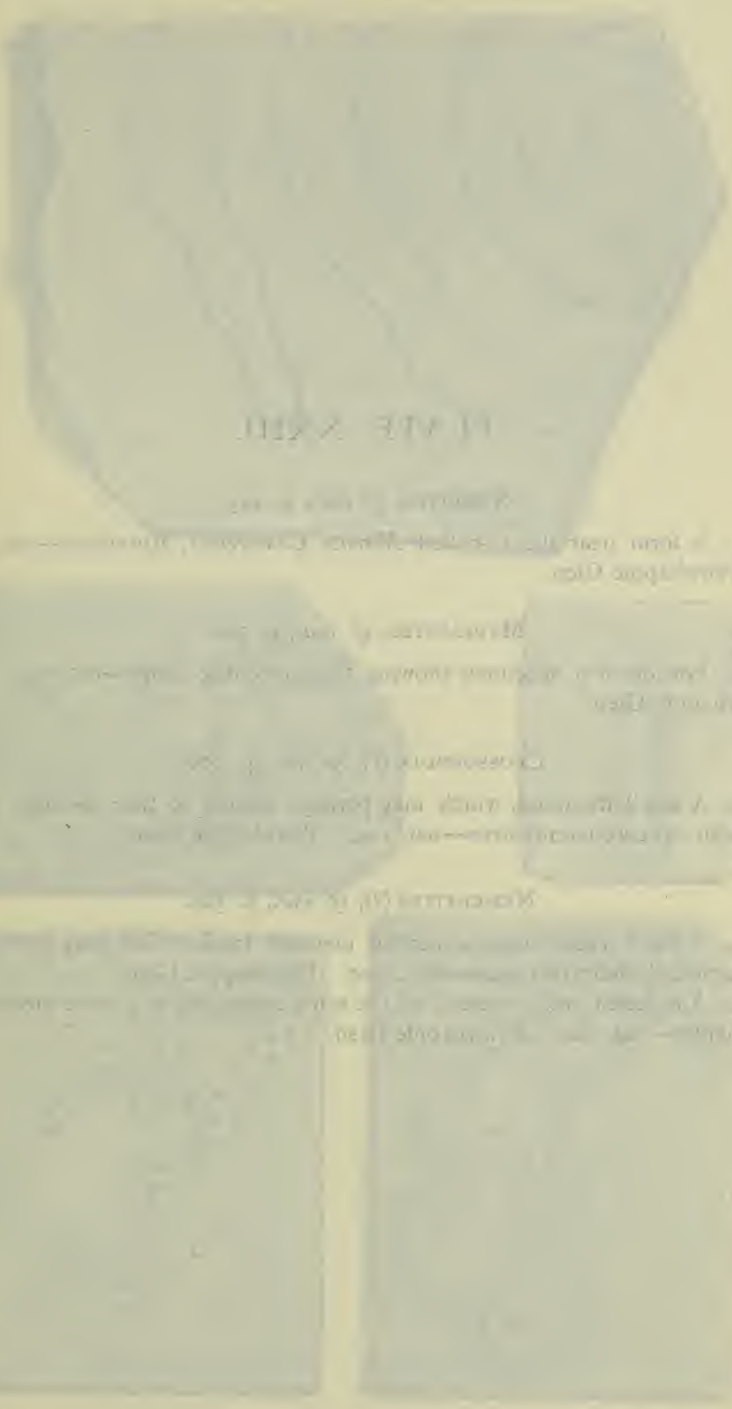


PLATE XXIII.

NEREITES, *sp. ind.*, p. 305.

Fig. 1. A form near the so-called *Nereites Cambrensis*, Murchison—nat. size. Penwhapple Glen.

MYRIANITES, *sp. ind.*, p. 306.

Fig. 2. Portion of a specimen showing the concentric loops—nat. size. Penwhapple Glen.

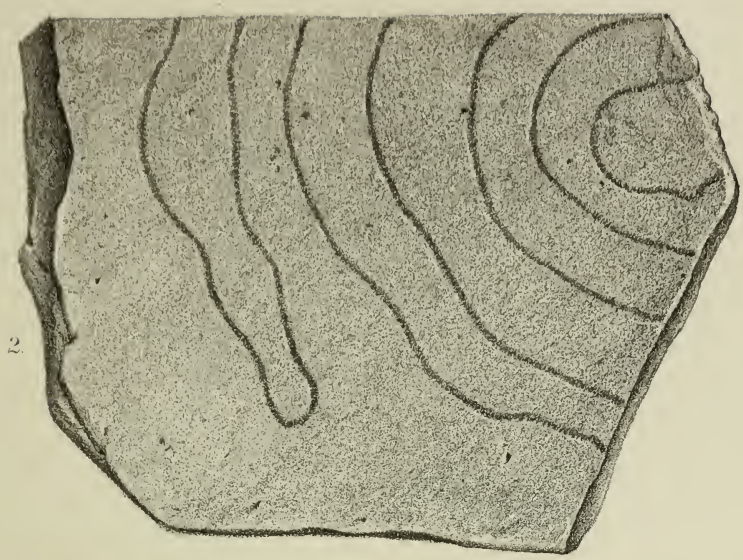
CROSSOPODIA (?), *sp. ind.*, p. 308.

Fig. 3. A small fragment, which may perhaps belong to this so-called genus, with delicate lateral striæ—nat. size. Penwhapple Glen.

NEMERTITES (?), *sp. ind.*, p. 309.

Fig. 4. A much convoluted, somewhat elevated track, which may perhaps be included under this name—nat. size. Penwhapple Glen.

Fig. 5. A different track referred to the same name, but of a more meandering nature—nat. size. Penwhapple Glen.



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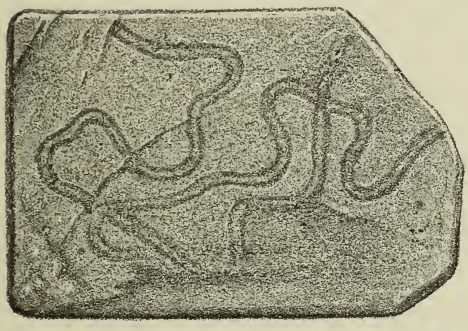

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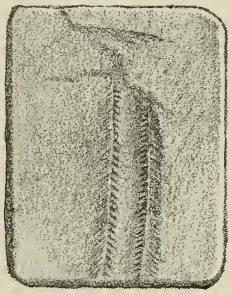

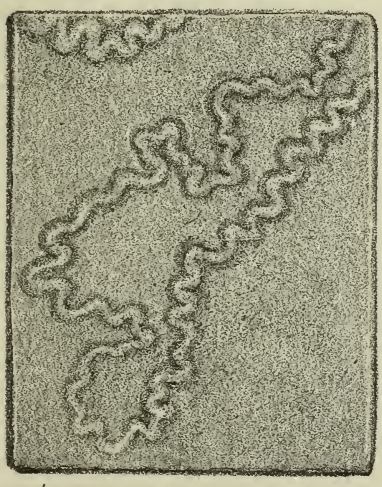

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PLATE XXIV.

MYRIANITES, *sp. ind.*, p. 306.

Fig. 1. Portion of a specimen exhibiting the concentric loops enlarging at the ends—nat. size. Penwhapple Glen.

MYRIANITES TENUIS, *M'Coy* (?), p. 306.

Fig. 2. Portion of an example presumed to belong to this so-called species—nat. size. Penwhapple Glen.

CROSSOPODIA SCOTICA, *M'Coy* (?), p. 307.

Fig. 3. An example which appears to correspond in its chief characters with this form—nat. size. Penwhapple Glen.

EIONE (?), *sp. ind.*, p. 309.

Fig. 4. A small fragment of shell exhibiting a series of consecutive depressions, which correspond with those described under the above name—nat. size. Penwhapple Glen.

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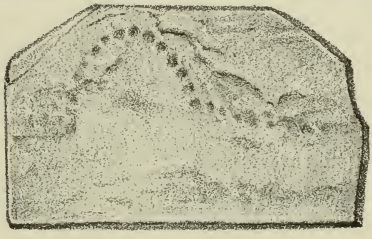

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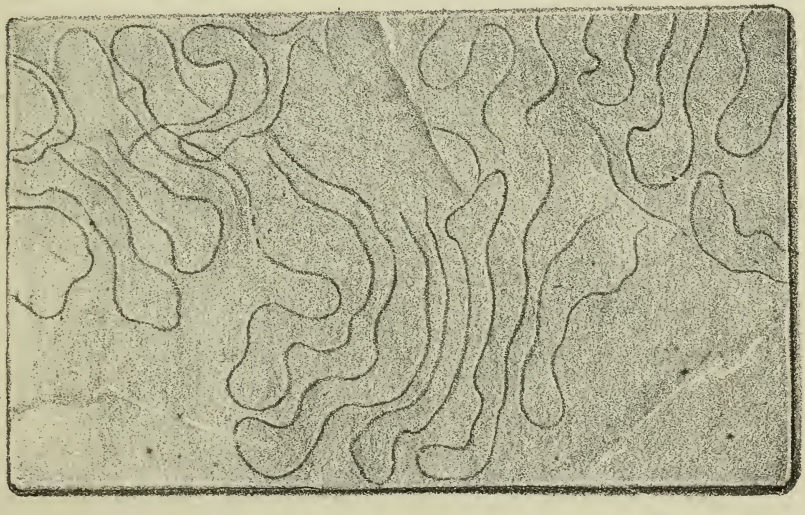

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SILURIAN FOSSILS

OF THE

GIRVAN DISTRICT IN AYRSHIRE

VOL. I.

THE PROTOZOA, ACTINOZOA, CRUSTACEA,
ANNELIDA, AND ECHINODERMATA

A MONOGRAPH

OF THE

SILURIAN FOSSILS OF THE GIRVAN DISTRICT IN AYRSHIRE

WITH SPECIAL REFERENCE TO THOSE CONTAINED IN THE "GRAY COLLECTION"

BY

H. ALLEYNE NICHOLSON

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VOL. I.

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DIRECTIONS TO BINDER.

Fasciculi I., II., and III. form Volume First.

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The Title to each Fasciculus to be placed before its respective part, and the half title to be cancelled.

The Plates in the three Fasciculi, with the corresponding explanatory pages preceding each, to be placed at end of Volume.